Volume 1 JULY 1927 Number 1

JOURNAL OF Paleontology

CONTENTS

JOURNAL OF PALEONTOLOGY

JOSEPH A. CUSHMAN, *Editor*

The Journal of Paleontology will be published four times a year by the Society of Economic Paleontologists and Mineralogists. Owing to delays consequent upon the forming of the new Society, the numbers for Volume 1 will not bear the regular dates that it is hoped can be started with Volume 2. It is expected that four numbers will be published in the calendar year 1927.

The subscription price to other than members of the Society is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Porto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, El Salvador, Bolivia, Colombia, Honduras, Nicaragua, Peru, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20), and for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

Claims for non-receipt of preceding numbers of the JOURNAL must be sent to the secretary-treasurer within three months of the date of publication in order to be filled gratis.

The JOURNAL will furnish reprints at cost. Orders should accompany corrected galley proof.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and advertising should be addressed to

MARCUS A. HANNA, *Secretary-Treasurer*
DRAWER C
HOUSTON, TEXAS

Communications in regard to manuscripts or purely editorial matters should be addressed to

JOSEPH A. CUSHMAN
76 BROOK ROAD
SHARON, MASSACHUSETTS

Application made for entry as second-class matter at the post-office at Chicago, Ill., under the Act of March 3, 1879.

PRINTED AT THE UNIVERSITY OF CHICAGO PRESS, U.S.A.

Volume 1 Number 1

JOURNAL OF PALEONTOLOGY

JULY 1927

FOREWORD

The launching of a new quarterly publication may well be an excellent opportunity for a statement of policy by the Editor. In order to help in an understanding of what he at least deems the wisest handling of the new *Journal*, the following brief survey is presented. While the papers to be published will tend toward helping the understanding of American stratigraphy through the microfaunas, it does not rule out papers on the larger fossils, especially where they may be directly correlated with the smaller ones. Papers dealing with the use of mineral grains for correlation will be included. It would seem that papers on foreign problems must take second place as there is so much to be done on American ones.

It would seem a wise policy to limit the size of papers so that no one paper will take up more than a third of a single issue, otherwise such papers if they cannot be condensed must be divided and published in parts. This is in fairness to authors and to readers as well. Large papers should seek publication elsewhere. Preference will be given to those papers which are short, well illustrated, and give information of stratigraphic value as well as descriptive matter.

In order to have well-balanced issues, it is necessary for the Editor to have plenty of papers; and all papers submitted will be given careful consideration, and if not accepted will be returned promptly.

In conclusion, the Editor disclaims any responsibility of approving papers or conclusions reached in them, as his work will be entirely that of seeing that papers conform to the general style adopted for the sake of uniformity. A leaflet entitled "Suggestions to Authors" may be obtained by those intending to submit papers.

JOSEPH A. CUSHMAN, *Editor*

SHARON, MASSACHUSETTS

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

The need for such an organization as the Society of Economic Paleontologists and Mineralogists was noted by several persons previous to the initial steps toward the organization of the group. The initial step was taken in the discussion which attended a dinner at Dallas, Texas, March 26, 1926. The dinner was attended by the following persons:

Mr. and Mrs. F. B. Plummer	Miss Grace Newman
Dr. Raymond C. Moore	Dr. Charles Schuchert
Dr. David White	Mr. and Mrs. Paul Applin
Dr. Lloyd W. Stephenson	Professor J. J. Galloway
Dr. Henry V. Howe	Dr. and Mrs. Charles E. Decker
Dr. and Mrs. W. M. Winton	Professor Julius Henderson
Mr. and Mrs. F. L. Whitney	Professor E. B. Branson

At the regular business meeting of the American Association of Petroleum Geologists the following morning, President DeGolyer asked for a resolution from the Association sponsoring the publication of a quarterly journal of micropaleontology. Dr. Schuchert moved that the Association express its approval of the founding of this publication, giving the executive committee power to take the necessary steps. The motion was seconded and carried.

Due to the fact that the papers on the program of the Eleventh Annual Meeting of the American Association of Petroleum Geologists, in session at Dallas, Texas, March 25–27, 1926, were behind schedule, the paleontological papers were given in a separate section the afternoon of March 27. Dr. Raymond C. Moore presided. A general discussion took place at this meeting, pertaining to the organization of the group into a section of the American Association of Petroleum Geologists and the publication of the authorized quarterly journal. With this end in view, a committee was appointed, consisting of F. B. Plummer, Raymond C. Moore, Mrs. Paul Applin, and F. L. Whitney (with a fifth member to be appointed by these four) to draw up a constitution and by-laws, and report back to the group at the next annual meeting of the American Association of Petroleum Geologists. Officers pro tempore were then elected, consisting of Henry V. Howe, president, Marcus A. Hanna, secretary-treasurer, and J. J. Galloway, editor. Dr. Howe took the chair for the remainder of the meeting which consisted of reading and discussing the papers of the program.

During the year Donald D. Hughes was appointed as a fifth member of the committee on constitution and by-laws. This committee drew up a constitution and by-laws which was presented at the Tulsa meeting, March 25, 1927.

Mr. F. B. Plummer, authorized by the executive committee of the American Association of Petroleum Geologists to take charge of the financing of the quarterly

journal, very actively led a campaign for funds toward the publication of the journal during the year. Contributions toward the publication of the *Journal of Paleontology* have been received from the following:

American Association of Petroleum Geologists
Ralph Arnold
E. DeGolyer
Floyd Dodson
David Donoghue
Gypsy Oil Company
Humble Oil and Refining Co.
Kirby Petroleum Company
Phillips Petroleum Company
F. B. Plummer
Pure Oil Company
Shell Company of California
Rio Bravo Oil Company
Sun Oil Company
Texas Christian University
Vacuum Oil Company
Paul Weaver
Skelly Oil Company
Philmack Oil Company
Roxana Petroleum Corporation
Barnsdall Oil Company
Edwin B. Hopkins
Henry L. Doherty and Co.
Julius Fohs
Brokaw, Dixon, Gardner, and McKee

Professor J. J. Galloway was appointed by Dr. Henry V. Howe as chairman of the program committee to co-operate with Dr. Sidney Powers in arranging a program for the Tulsa meeting of the group. Two days of meetings were held at Tulsa, Oklahoma, March 23 and 25, 1927. The program for March 23 consisted of exhibits of fossils, minerals, description of technique and methods, and round-table discussions. The program of March 25 consisted of organization of the Society of Economic Paleontologists and Mineralogists and the reading and discussion of papers.

Dr. Henry V. Howe, president pro tempore, presided. The following constitution was adopted the morning of March 25, 1927:

THE CONSTITUTION OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

ARTICLE I. NAME

This society shall be known as the "Society of Economic Paleontologists and Mineralogists." It is affiliated with the AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS.

ARTICLE II. OBJECT

The object of the Society is to promote the science of stratigraphy through research in paleontology and sedimentary petrography, especially as it relates to petroleum geology.

ARTICLE III. MEMBERSHIP

The Society shall be composed of members, associate members, honorary members, correspondents, and patrons.

1. Members shall be persons engaged in stratigraphic studies as applied to petroleum development, and who have been duly elected members or associate members in the AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS.

2. Associate members shall be other persons engaged in stratigraphic studies.

3. Honorary members shall be persons of distinguished achievement in the field of stratigraphy, who have contributed to phases of the science connected especially with petroleum development.

4. Correspondents shall be persons distinguished for attainments in stratigraphy as applied to petroleum geology, but not resident in North America.

5. Patrons may be designated by the Council in recognition of favors bestowed on the Society.

ARTICLE IV. OFFICERS

The officers of the Society are President, Vice-President, Secretary-Treasurer, and Editor. These officers and the retiring president constitute an executive committee to be called the Council.

1. The President shall discharge the usual duties of a presiding officer at all meetings of the Society or Council.

2. The Vice-President shall assume the duties of the President in case of his absence.

3. The Secretary-Treasurer shall keep record of the proceedings of the Society, and a complete list of the membership. He shall attend to the preparation and mailing of notices and other materials required in the business of the Society. The Secretary-Treasurer shall have custody of all funds of the Society, and shall keep a detailed account of receipts and disbursements.

4. The Editor shall supervise all matters connected with the publications of the Society, under the direction of the Council. He shall take care of all publications sent to the Society.

5. The Council has full executive authority, and also legislative powers of the Society in the intervals between meetings, provided that all legislative acts of the Council shall be subject to the review of the Society at its next following meeting. The Council shall receive nominations for membership of all grades, election requiring favorable vote of four members of the Council. The Council shall have power to fill vacancies ad interim in any of the offices of the Society.

6. The officers shall be elected annually. The President shall be ineligible for re-election within a period of three years.

ARTICLE V. MEETINGS

The Society shall hold at least one stated meeting a year, which shall be designated as the annual meeting. The annual meeting shall be held at a time and place most convenient for the majority of members, and shall be designated by the Council. In general, it shall be held in connection with the annual meeting of the AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS.

At this meeting the proceedings of the preceding meeting shall be read, the members elected during the year announced, all Society business transacted, scientific papers read and discussed, and officers for the ensuing year elected.

The program for the annual meeting shall be formulated by the Council, or such persons as are appointed by the Council.

ARTICLE VI. PUBLICATIONS

All publications of the Society shall be under the immediate control of the Council.

ARTICLE VII. SECTIONS

Local Sections may be granted upon the recommendation to the Council and the passing of the recommendation by a two-thirds majority vote of the members present at the annual business meeting, provided the petition is signed by at least five members of the AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS.

ARTICLE VIII. AMENDMENTS

This constitution may be amended at any annual meeting by a two-thirds majority vote of the members present at the annual business meeting, provided the proposed amendment has been signed by at least five members, and that it has been mailed to each member at least three months previous to the annual business meeting.

The by-laws may be amended by a majority vote of the members present at the annual business meeting.

BY-LAWS

I. MEMBERSHIP

SECTION 1.—All members of the AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS in good standing, whose work is largely in paleontology or sedimentary petrography, may, on application to the Council of this Society, be elected as members.

SEC. 2.—Persons not members or associate members of the AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS may, on recommendation of two members of this Society, be elected by the Council to associate membership.

SEC. 3.—Honorary members shall be elected only on unanimous vote of the Council of the Society, and approval of two thirds of the members at a regular business meeting.

SEC. 4.—Correspondents shall be elected by unanimous vote of the Council.

SEC. 5.—Patrons shall be designated under conditions stipulated by the Council.

SEC. 6.—The annual dues for members shall be four dollars ($4.00); the annual dues for associate members shall be six dollars ($6.00). No person shall be accepted as a member or associate member unless he pays the dues for the year within three months after notification of his election. The annual dues are payable to the Secretary-Treasurer of the Society on July 1st of each year. No dues shall be assessed upon honorary members, correspondents, or patrons.

SEC. 7.—Non-payment of dues shall deprive members of voting and of receiving the publications of the Society. An arrearage of dues for two years shall be considered a notice of withdrawal.

II. OFFICERS

SECTION 1.—The Council shall designate two nominees for each office of the Society, but other nominations may be made at the time of election.

SEC. 2.—The officers shall be elected by ballot at an announced business session at the annual meeting of the Society. Majority vote of the members present constitutes election.

III. PUBLICATIONS

SECTION 1.—All matters concerning publications issued by the Society shall be under control of the Council.

SEC. 2.—A copy of each publication, except as directed by the Council, shall be transmitted without charge to all members of the Society in good standing.

SEC. 3.—A publication fund shall be established, consisting of an assignment of a portion of dues as designated by the Council, and donations made to aid publication.

IV. FINANCIAL METHODS

SECTION 1.—No financial obligations shall be contracted without express sanction of the Society or Council, but all ordinary incidental running expenses have sanction without special action.

SEC. 2.—Statements of accounts charged to the Society, other than miscellaneous running expenses, shall be approved by the President before the Secretary-Treasurer pays the amount out of funds of the Society not otherwise appropriated, and the receipted bill shall be held as the Secretary-Treasurer's voucher.

SEC. 3.—At each annual meeting the President shall call on the Society to choose two members who are not members of the Council, to whom shall be referred the books of the Secretary-Treasurer, duly posted and balanced. The auditors shall examine all accounts and vouchers, and render a report to the meeting of the Society.

Following this, the following officers were elected: J. J. Galloway, president; Donald D. Hughes, vice-president; Marcus A. Hanna, secretary-treasurer; and Joseph A. Cushman, editor.

The regular business meeting of the Society of Economic Paleontologists and Mineralogists was held the afternoon of March 25, 1927. At this meeting two petitions for sections of the Society were approved by the members present. One was the Pacific Section,[1] and the other the Fort Worth Section.

The following members or associate members of the American Association of Petroleum Geologists were charter members of the Society of Economic Paleontologists and Mineralogists:

CHARTER MEMBERS OF SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

Adkins, W. S., Bureau of Economic Geology, University of Texas, Austin, Texas
Alexander, C. I. Jr., Department of Geology, Princeton University, Princeton, New Jersey
Anderson, Carl B., 1131 South Owasso Street, Tulsa, Oklahoma
Applin, Mrs. Paul, Rio Bravo Oil Company, Houston, Texas
Baker, William A. Jr., Cia. Transcontinental de Petroleo, S.A., Apartado 657, Tampico, Tamps., Mexico
Beede, J. W., Dixie Oil Company, San Antonio, Texas
Bowser, Frank W., Texas Christian University, Department of Geology, Fort Worth, Texas
Brehm, R. C., P. O. Box 2100, Denver, Colorado
Buchanan, Geo. S., Carter Oil Company, Tulsa, Oklahoma
Cartwright, Lon D. Jr., 800 Goliad Street, Beaumont, Texas
Coryell, Horace Noble, Columbia University, New York, New York
Cram, Ira H., Pure Oil Company, Tulsa, Oklahoma
Cushman, Joseph A., Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts
Decker, Charles E., University of Oklahoma, Norman, Oklahoma
Doane, George H., 334 South Coronado Street, Los Angeles, California
Dodson, Floyd C., 919 West Beauregard Street, San Angelo, Texas
Dorr, James B., Huasteca Petroleum Co., Apartado 94, Tampico, Tamps., Mexico
Driver, Herschel L., 630 West Palm Drive, Glendale, California
Edwards, E. C., 1120 South Colorado Avenue, San Angelo, Texas
Ellisor, Miss Alva C., Humble Oil & Refining Co., P. O. Box D, Houston, Texas
Fletcher, Corbin D., Gulf Refining Co. of Louisiana, Shreveport, Louisiana
Galloway, J. J., Columbia University, New York, New York
Gardiner, Thomas M. Jr., Shell Oil Co. of California, P. O. Box 672, Bakersfield, California
Gardner, Julia, U. S. Geological Survey, Washington, D.C.
Gilboe, John D., 352 Newport Avenue, Long Beach, California
Goudkoff, Paul P., 830 South Park View Street, Los Angeles, California
Green, Frank C., 1434 South Cincinnati Avenue, Tulsa, Oklahoma
Grim, Ralph E., Mississippi Geological Survey, University of Mississippi, University, Mississippi
Hanna, G. Dallas, Associated Oil Company, 79 New Montgomery Street, San Francisco, California
Hanna, Marcus A., P. O. Drawer C, Houston, Texas
Hanson, Ed. V., Roxana Petroleum Corp., 2117 Post-Dispatch Building, Houston, Texas
Harlton, Bruce H., Amerada Petroleum Corp., P. O. Box 2022, Tulsa, Oklahoma
Hawtof, E. M., Bureau of Economic Geology, University of Texas, Austin, Texas
Hodson, Floyd, Standard Oil Co. of Venezuela, Apartado 85, Maracaibo, Venezuela

[1]Officers for the ensuing year are: George H. Doane, chairman, and Guy E. Miller, secretary-treasurer. Meetings are to be held monthly from September to May.

Hodson, Mrs. Helen K., Standard Oil Co. of Venezuela, Apartado 85, Maracaibo, Venezuela
Honess, Chas. W., Gypsy Oil Company, Tulsa, Oklahoma
Howe, Henry V., Louisiana State University, Baton Rouge, Louisiana
Hughes, Donald D., Marland Oil Co. of California, 417 South Spring Street, Los Angeles, California
Hutson, E. B., 516 Wyandotte Avenue, Shreveport, Louisiana
Israelsky, Merle C., Palmer Corporation, P. O. Box 11, Shreveport, Louisiana
Kaufmann, Godfrey F., Transcontinental Petroleum Co., Apartado 657, Tampico, Tamps., Mexico
Keyte, I. A., 317 East San Rafael Street, Colorado Springs, Colorado
Knicker, Hedwig T., Phillips Petroleum Company, San Angelo, Texas
Kornfeld, Moses M., Roxana Petroleum Corp., Athletic Club Building, Tulsa, Oklahoma
Macready, George A., 256 East Glenarm Street, Pasadena, California
Maucini, Jos. J., Marland Oil Co. of Texas, Amarillo, Texas
May, Art R., Shell Oil Co. of California, P. O. Box 672, Bakersfield, California
Miller, Guy E., Shell Co. of California, 1821 E. Third St:, Long Beach, California
Moore, Raymond C., University of Kansas, Lawrence, Kansas
Moreman, W. L., Texas Christian University, Fort Worth, Texas
Myers, John C., Roxana Petroleum Corp., P. O. Box 1865, Houston, Texas
Newman, T. F., 608 Alexander Building, Abilene, Texas
Nightingale, William T., Ohio Oil Company, Casper, Wyoming
Owens, Frith C., Humble Oil & Refining Co., Houston, Texas
Petty, Dabney E., No. 10 Tenth Street, San Antonio, Texas
Plummer, F. B., Amerada Petroleum Corp., Fort Worth, Texas
Reeside, John B. Jr., P. O. Box 175, Hyattsville, Maryland
Rice, Elmer M., Pure Oil Company, Mexia, Texas
Rohwer, F. W., 624 Pine Street, Boulder, Colorado
Roundy, Paul V., U. S. Geological Survey, Washington, D.C.
Ryniker, Chas., Gypsy Oil Company, Tulsa, Oklahoma
Scott, Gayle, Texas Christian University, Fort Worth, Texas
Seashore, Paul T., Humphreys Corporation, Esperson Building, Houston, Texas
Selig, A. L., 843 Dudley Drive, Shreveport, Louisiana
Sellards, E. H., Bureau of Economic Geology, University of Texas, Austin, Texas
Smith, A. J., P. O. Box 592, Kiefer, Oklahoma
Stangl, Frank J. Jr., 1212 Hemphill Street, Fort Worth, Texas
Stephenson, L. W., U. S. Geological Survey, Washington, D.C.
Stiles, Elizabeth, P. O. Drawer C., Houston, Texas
Storm, L. W., Sun Oil Company, Dallas, Texas
Thalmann, Hans E., La Corona Co., Apartado 238, Tampico, Tamps., Mexico
Thomas, N. L., Pure Oil Company, Mexia, Texas
Trager, Earl A., Earl Oliver & Co., P. O. Box 188, Ponca City, Oklahoma
Trowbridge, A. C., 1182 East Court Street, Iowa City, Iowa
Vaughan, T. Wayland, Scripps Institution, La Jolla, California
Waters, James A., Sun Oil Company, Dallas, Texas
Weinzierl, Laura L., Marland Oil Co. of Texas, Houston, Texas
White, Maynard P., 460 West 144th Street, New York, New York
Winton, W. M., Texas Christian University, Fort Worth, Texas
Young, Karl E., Rycade Oil Corporation, Humble Building, Houston, Texas

APPLICANTS FOR FULL OR ASSOCIATE MEMBERSHIP IN A. A. P. G. NOT YET ACTED UPON

Galloway, Alan J., P. O. Box 672, Bakersfield, California
Holland, L. F., 1768 North La Brea Avenue, Hollywood, California
Miller, Charles W., 209 South Maple Street, Sapulpa, Oklahoma
Millison, Clark, 302 North Clifton Street, Wichita, Kansas
Monical, Doska W. E., Shell Co. of California, 1821 E. 3d Street, Long Beach, California
Rolshausen, F. W., 903 Humble Bldg., Houston, Texas
Wissler, Stanley S., Union Oil Co. of California, Los Angeles, California
Youngmeyer, Ray, 125 North Volutsia Street, Wichita, Kansas

MARCUS A. HANNA, *Secretary*

DESCRIPTION OF OSTRACODES

P. V. ROUNDY[1]
U.S. Geological Survey, Washington, D.C.

In the classification of living ostracodes the generic distinctions are based upon the anatomy of the animal and not, as in the Foraminifera, on the characters of the shell. The paleontologist having only the shell or carapace to study must, however, base his generic distinctions upon characters of the shell which may be selected in a somewhat arbitrary manner. The paleontologist of the past placed different values upon these shell characters from the paleontologist of the present, and probably the paleontologist of the future will place still different values upon them. Even good figures often leave one in doubt concerning certain characters, such as overlap, marked changes in curvature of the surface, contact margins of the valves, hinge character, etc. Therefore, in order that the work of our day may stand the test of time and that our species and genera can with reasonable assurance be identified by our co-workers, our specific descriptions should be made definite and reasonably complete.

In observing the general shape and surface ornamentation of bivalve ostracode specimens, it is very important that the specimen be so placed that the plane of juncture of the two valves is either perpendicular to, or coincident with, the line of vision. A slight amount of tilting away from these positions often results in a surprisingly changed outline. If a specimen with ends of unequal thickness is attached by its side to a flat mount, the plane of juncture of the two valves will very seldom be parallel to the base of the mount. In viewing the specimen through the microscope, it is therefore advisable to place the mount upon a small ball of modeling-clay so that by tilting, the specimen may be correctly oriented.

Overlap, although usually considered as a generic rather than a specific character, is such an important aid in identification that its presence or absence should be mentioned in the description of new species. The general usage has always been to consider as equivalve all species where the external margins of the two valves meet approximately even, although there may be a decided internal overlap or inequality.

Perhaps one of the most important and helpful parts of a specific description is the discussion of comparisons with related species. By following a definite outline, descriptions of species will be made more uniform and probably clearer and more usable. Also important data are less liable to be omitted. The following outline is therefore offered for consideration, not as a perfected model, but rather as a suggestion.

[1] Published by permission of the director of the U. S. Geological Survey.

OUTLINE FOR DESCRIPTION OF OSTRACODE SPECIES

HEADING should comprise both a generic and a specific name.

Generic name.—If the generic relationship is doubtful, the name should be followed by a "?."

Specific name.—Where a definite specific name is used, it should be followed by "n. sp." (or "sp. nov.") if the species is new, or by the name of the author if the species has already been described. If the identification is uncertain, a "?" is placed after the author's name; if an identification is merely suggested or a resemblance noted "cf." is placed between the generic name and the species name; if a definite relationship is established but the degree of relationship in doubt "aff." is inserted in the same place. If a species can be determined as new, but if the material is not adequate for a good description, a specific name is omitted and only "n. sp." is used. If the species can be differentiated but not identified, they are indicated by some such symbol as "sp. A," "sp. B," etc. If only the genus is identified but no specific relationship suggested, the generic name is followed merely by "sp." or "sp. indet."

DESCRIPTION.

1. General shape in outline as viewed from side. General position of greatest height and greatest thickness. Character of hinge line, dorsal margin, etc. May include seen from top, ventral side, or end. If question arises as to which end is anterior, it should be discussed here.

2. Overlap. Relative size of valves to be given and overlap detailed. Mention here hinge structure if any noted.

3. Surface features. Smooth, pitted, reticulate, nodes, ridges, sulcuses, flanges, spines, etc.

4. Measurements. Length, height, thickness.

5. Discussion. Give comparisons with and differences from related species. Discussion of generic relation if any is needed, and any other general matter of interest.

6. Horizon and locality.

(1 to 3 should be condensed and to the point and, if not too long, a single paragraph. 5 is usually written in less-condensed English.)

DESCRIPTION OF FORAMINIFERA

JOSEPH A. CUSHMAN

The preceding outline for description of ostracodes may in general be applied to the Foraminifera.

The usual procedure in the description of Foraminifera is to give the general characters of the test first, followed by the more detailed structures. The author has adopted the following order: general appearance, chambers, sutures, wall, aperture, and color. These five or six distinctive groups of descriptive characters are set off from one another by semicolons for clearness.

1. General appearance will include relative size, proportions, characters of the periphery, changes in plan of development, condition of attachment, and such other general points as are not included in the following more detailed characters:

2. Chambers including number, relative size and shape, and arrangement.

3. Sutures, including amount of depression or elevation; clearness; amount of limbation, if any; changes in various parts or sides of the test; direction; straight or, if curved, the relative amount; relations to the ornamentation.

4. Wall, including relative thickness; materials of which composed; kind and relative amount of cement; finish of the exterior; relative size of perforations, if a perforate form; ornamentation, especially changes in different stages of development or in different parts of the wall.

5. Aperture, including changes of position at different stages of development, relation to peculiar structures or modifications of the chamber, development of neck or lip or ornamentation directly connected with the aperture itself.

6. Color, usually not evident in fossil forms although occasionally of decided importance.

Measurements, especially in different dimensions and ranges in size, are important.

Localities should be given very definitely and with sufficient detail that later collectors may find the type locality.

Comparison with related species is important, especially the points in which the species under discussion differs from its closely related forms.

The relative value of certain structures should be noted: for example, in the Lagenidae broadly keeled forms often show all gradations to forms without keels in the same sample, other characters are of varietal value only and not specific. A study of the relative value of characters in each family will be an enlightening source of facts bearing on the relative value of certain descriptive characters.

The place of deposit of the type specimen should be given with the catalogue number if possible, so that future workers may know where to find the specimen for

study. The type specimen is the court of last appeal, and what it shows must be taken as the basis for the species whatever the author's description may have said of it.

Much care by the author at the time of description will save controversies later and will mean the placing of his work on a firm foundation.

Figures should aim for accuracy in detail and to fully illustrate the points in the description.

SOME PENNSYLVANIAN FORAMINIFERA OF THE GLENN FORMATION OF SOUTHERN OKLAHOMA

BRUCE H. HARLTON[1]
Amerada Petroleum Corporation, Tulsa, Oklahoma

This paper describes certain species and varieties of the smaller forms of Foraminifera[2] of the Mid-Continent oil fields. Until very recently only slight attention was given to this phase of paleontology in the Mid-Continent region. The following contribution is made in an effort to enlarge upon the present knowledge and to form the basis for further study.

In Paleozoic well-cuttings the proportion of Foraminifera to other fossils is approximately ten to one. Furthermore, a 2-ton drill is made to crush fragments to a diameter of less than 1 millimeter. Hence foraminiferal data are relatively plentiful, and the fossils are well preserved.

The greatest economic value of a knowledge of Foraminifera lies in the fact that by its judicious use the geological age of the various formations penetrated by the drill can be determined. With this knowledge the structure and the geologic history are made available for application to the finding of oil in new territories or to the determination of the depths of the producing horizons in proved and semi-proved areas.

It is true that correlations can be made by the comparison of lithologic characteristics and by detailed petrographic methods, but this information is not as reliable as that given by Foraminifera because it takes no account of time.

The Foraminifera here described are all small forms. The absence of fragments of larger Foraminifera indicates that there were no species of large size in these seas.

In the Carboniferous limestone ("Mississippi lime," Oswego, Otterville, etc.) numerous spherical concretions are found. These were formed by the agency of animals secreting carbonate of lime. The sea appears to have deposited its excess of mineral constituents in accordance with chemical and physical laws, without the intervention, to any great extent, of animal life. The spheroids of these rocks have generally a radiate structure and in section show one or more concentric rings; the center is often occupied by a foreign body, such as a minute crystal, the fragment of a coral, or even a foraminifer, though more often there is no observable nucleus. The oölitic grains are normally nearly spheroidal; but they also assume ovoid, elongate, or quite irregular forms.

[1] Published by permission of the Amerada Petroleum Corporation. The writer wishes to express appreciation for helpful suggestions and for careful criticism to Dr. Joseph A. Cushman and Professor J. J. Galloway.

[2] The type set of fossils upon which this paper is based has been deposited with the U. S. National Museum.

SYSTEMATIC DESCRIPTION

ORDER FORAMINIFERA

FAMILY HYPERAMMINIDAE

Genus HYPERAMMINA Brady, 1878

HYPERAMMINA ELONGATA var. CLAVATULA (Howchin)

Plate 1, figs. 1 *a*, *b*[1]

Test free, clavatoform; primordial end slightly inflated, rounded, closed; tubular portion straight or slightly curved; uniform diameter throughout; wall thin, finely arenaceous, smooth, sometimes marked by slightly depressed lines; aperture formed by the open end of the tube. Length, 0.7 mm. to 1.2 mm.

Upper Caney, lower Pennsylvanian (this member was included and termed "Springer" by Goldston in the lower Glenn formation) (surface outcrop), SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ of Sec. 16, T. 6 S., R. 2 E., Love County, Oklahoma, about $8\frac{1}{2}$ miles south of Ardmore.

FAMILY AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

AMMODISCUS INCERTUS (d'Orbigny)

Plate 1, figs. 2 *a–e*

Operculina incerta D'ORBIGNY, in De la Sagra, Hist. Phis. Pol. Nat. Cuba, 1839, "Foraminiferes," p. 49, pl. 6, figs. 16, 17; Spanish ed., 1840, p. 71, pl. 6, figs. 16, 17.

Spirillina arenacea WILLIAMSON, Recent Foraminifera of Great Britain, 1858, p. 93, pl. 7, fig. 203.

Trochammina squamata, var. *incerta* JONES and PARKER, Quar. Jour. Geol. Soc., vol. 16, 1860, p. 304.—PARKER and JONES, Appendix to W. B. CARPENTER, PARKER, and JONES, Introd. Study Foram., 1862, p. 312.

Trochammina incerta W. B. CARPENTER, PARKER, and JONES, Introd. Study Foram., 1862, p. 141, pl. 11, fig. 2.—HAEUSLER, Ann. Mag. Nat. Hist., ser. 5, vol. 10, 1882, p. 52, pl. 3.

Ammodiscus incertus H. B. BRADY, Rep. Voy. *Challenger*, Zoölogy, vol. 9, 1884, p. 330, pl. 38, figs. 1–3.—SHERBORN and CHAPMAN, Jour. Roy. Micr. Soc., 1889, p. 484, pl. 11, fig. 7.—BURROWS, SHERBORN, and BAILEY, Jour. Roy. Micr. Soc., 1890, p. 552, pl. 8, fig. 8.—J. WRIGHT, Proc. Roy. Irish Acad., vol. 1, 1891, p. 468.—CHAPMAN, Jour. Roy. Micr. Soc., 1892, p. 326, pl. 6, fig. 11.—EGGER, Abh. kön. bay Akad. Wiss. München, vol. 18, 1893, p. 263, pl. 5, figs. 35, 36.—GOËS, Kongl. Svensk. Vet. Akad. Handl., vol. 25, no. 9, 1894, p. 31, pl. 6, figs. 238, 239.—CHAPMAN, Proc. Zoöl. Soc. London, 1895, p. 17; Ann. Mag. Nat. Hist., ser. 6, vol. 16, 1895, p. 315, pl. 11, figs. 8, 9.—GOËS, Bull. Mus. Comp. Zoöl., vol. 29, 1896, p. 34.—FLINT, Rep. U. S. Nat. Mus., 1897 (1899), p. 278, pl. 23, fig. 2.—MILLETT, Jour. Roy. Micr. Soc., 1899, p. 362.—EIMER and FICKERT, Zeitschr. wiss. Zoöl., vol. 65, 1899, p. 614, fig. 32 (in text).—RHUMBLER, Zeitschr. allgem. Phys., vol. 2, 1902, p. 1, fig. 18; Arch. Protistk., vol. 3, 1903, p. 280, fig. 129 (in text).—SIDEBOTTOM, Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 49, No. 5, 1905, p. 5.

Ammodiscus tenuis H. B. BRADY, Quar. Jour. Micr. Sci., vol. 21, 1881, p. 51; Rep. Voy. *Challenger*, Zoölogy, vol. 9, 1884, p. 332, pl. 38, figs. 4–6.—GOËS, Kongl. Svensk. Vet. Akad. Handl., vol. 25, No. 9, 1894, p. 31, pl. 6, figs. 240, 241.—CHAPMAN, Proc. Zoöl. Soc. London, 1895, p. 18.—FLINT, Rep. U. S. Nat. Mus., 1897 (1899), p. 279, pl. 23, fig. 1.—RHUMBLER, Arch. Protistk., vol. 3, 1903, p. 281, fig. 130 (in text).

[1] All illustrations are drawn by the author with camera lucida.

Test free, planispiral, subcircular or ovoid proloculum and a long undivided tubular second chamber, coiled regularly in one plane, gradually increasing in size; growth lines visible on the outside of last chamber; wall finely arenaceous; aperture formed by the open end of the tube. Diameter, 0.5 mm. to 0.85 mm.

Upper Glenn. SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

Genus LITUOTUBA Rhumbler, 1895

LITUOTUBA CENTRIFUGA (H. B. Brady)

Plate 1, figs. 3 *a–h*

Trochammina centrifuga H. B. BRADY, Carbonif. Foram. Pal. Soc., 1876, p. 74, pl. 2, figs. 15–20.

Test free, relatively very small, planispiral, later portions crosier-shaped, early portion with subcircular or ovoid proloculum and a long undivided second chamber, coiled in one plane, gradually increasing in size; linear portion long, straight, growth lines visible on outside of last chamber; wall finely arenaceous, aperture formed by the open end of the tube. Length, 0.4 mm. to 0.6 mm.

Lituotuba centrifuga begins its growth on the same plan as *Ammodiscus incertus*, and in its later stage it changes abruptly from spiral to rectilinear. The number of whorls is variable. The linear portion also varies much in length. The planospiral portion of the distorted specimens, as shown in figures 3 *e–h*, are asymmetrically coiled and quite frequently coiled like a ball of twine. *Lituotuba centrifuga* has been found only in the Upper Strawn, Canyon and the Upper Glenn formation of Southern Oklahoma; due to this it may be regarded as an index fossil.

The well-preserved specimens are rather rare in occurrence; and the greatest percentage of the forms are distorted, both in Texas and in Southern Oklahoma.

Mineral Wells formation (Texas) and lower part of Upper Glenn (southern Oklahoma) (surface outcrop) shale exposure just east of Mineral Wells, 1 mile north of main highway east, Texas.

FAMILY REOPHACIDAE

Genus NODOSINELLA Brady, 1876

NODOSINELLA GLENNENSIS Harlton, n. sp.

Plate 1, figs. 4 *a–c*

Test free, large and stout, straight and curved, uniserial, elongate, tapering; chambers numerous, usually six; wall finely arenaceous, smooth; aperture single, simple terminal. Length, 2 mm. to 2.8 mm.

Upper Glenn (surface outcrop), ¼ mile north of SE. cor. of Sec. 9, T. 6 S., R. 2 E., Love County, Oklahoma, about 7 miles south of Ardmore. Holotype, U. S. National Museum, No. 71376.

NODOSINELLA ARDMORENSIS Harlton, n. sp.

Plate 1, figs. 5 *a–e*

Test free, straight or curved, cylindrical or somewhat compressed, elongate, slightly tapering; chambers few, more or less inflated; wall finely arenaceous, smooth; aperture single, simple, terminal. Length, 1 mm. to 1.2 mm.

Lower Glenn (surface outcrop), SW. ¼ of NW. ¼ of NE. ¼ of Sec. 16, T. 6 S., R. 2 E., Love County, Oklahoma, about 8½ miles south of Ardmore. Holotype, U. S. National Museum, No. 71377.

FAMILY NONIONIDAE

Genus BRADYINA Moeller, 1878

BRADYINA HOLDENVILLENSIS Harlton, n. sp.

Plate 2, figs. 1 *a–c*

Test free, subspherical, nautiloid, consisting usually of five inflated chambers in the last formed whorl, each tending to embrace the following external chamber, first chamber larger in width than the preceding ones; non-umbilicated; sutures slightly depressed; wall subarenaceous, smooth, aperture multiple, row of pores along the sutures between chambers. Length, 0.6 mm. to 1.2 mm.

Upper Glenn (surface outcrop), SW. ¼ of SW. ¼ of NW. ¼ of Sec. 20, T. 5 S., R. 1 E., Carter County, Oklahoma, about 4 miles north of Ardmore. Holotype, U. S. National Museum, No. 71391.

FAMILY LITUOLIDAE

Genus ENDOTHYRA Phillips, 1846

ENDOTHYRA RADIATA H. B. Brady

Plate 2, figs. 2 *a–c*

Endothyra radiata H. B. BRADY, Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 97, pl. 5, figs. 10–12.

Test free, planispiral, nautiloid, laterally asymmetrical, closely coiled throughout, umbilicate; periphery sharp, chambers very numerous, narrow; sutures usually marked by lines; wall subarenaceous, of calcareous particles with much calcareous cement; aperture crescentiform, opening at the base of the apertural face. Diameter, 0.5 mm.

Lower Glenn, center of north line of Sec. 14, T. 5 S., R. 1 E. (surface outcrop), Carter County, Oklahoma, about 2 miles south of Ardmore.

ENDOTHYRA BOWMANI Phillips

Plate 2, figs. 3 *a–d*

Endothyra bowmani PHILLIPS, Proc. Geol. and Polytech. Soc. W. Riding Yorks., vol. 11, 1845, p. 279, pl. 7, fig. 1.

Rotalia baileyi HALL, Trans. Albany Instit., vol 4, 1858–64, p. 34.

Endothyra bowmani H. B. BRADY, Mem. Geol. Survey Scotland; Explan. Sheet 23, 1873, pp. 63, 95, etc.

Test free, nautiloid; chambers numerous, inflated, usually consisting of two or three oblique whorls, only last one visible on exterior; sutures depressed; peripheral margin thick, rounded, lobulate; wall subarenaceous, of calcareous particles with much calcareous cement, smooth; aperture a curved slit at the base of the apertural face, on the inner periphery. Diameter, 0.5 mm. to 1.3 mm.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

ENDOTHYRA AMERADAENSIS Harlton, n. sp.

Plate 2, figs. 4 *a–c*

Test free, planispiral, nautiloid; whorls about three, almost involute, umbilicated; chambers numerous, subglobular, usually ten in the last formed whorl; sutures strongly limbate; wall sub-arenaceous, of calcareous particles with much calcareous cement; aperture an ovoid opening at the base of the last chamber extending almost over the entire triangular apertural face. Diameter, 0.75 mm.

This species has a striking resemblance to *Endothyra globulus* (d'Eichwald) described by H. B. Brady, Carbonif. Foram. Pal. Soc., Vol. 30, 1876, pl. 5, fig. 9, in which publication he states that it is a cast of the interior of a large specimen. Although figure 9 is grouped with figures 7 and 8, which are characteristic likenesses of *Endothyra globulus*, the author is decidedly of the opinion that the fossil shown in figure 9 is an entirely different form. Figure 9 therefore does not represent the fossil *Endothyra globulus;* hence, in spite of the fact that the fossil described above and named *Endothyra ameradaensis* resembles Brady's figure 9, the author feels justified in describing the specimen as a new species.

Upper Glenn, SW ¼ of NW. ¼ of Sec. 20, T. 5 S., R. 2 E. (surface outcrop), Carter County, Oklahoma, about 4 miles south of Ardmore. Holotype, U. S. National Museum, No. 71383.

ENDOTHYRA GLOBULUS d'Eichwald

Plate 2, figs. 5 *a, b*

Nonionina globulus, D'EICHWALD, Lethaea Rossica, vol. 1., 1860, p. 350, Esp. 24, pl. XXII, figs. 17 *a, b, c.*

Endothyra globulus, H. B. BRADY, Carbonif. Foram. Pal. Soc., 1876, p. 95, pl. 5, figs. 7–9.

Test free, nautiloid, nearly symmetrically bilateral, chambers numerous, usually ten or more in the last-formed whorl; umbilici sometimes depressed; sutures distinct; peripheral margin thick and round but little, if at all, constricted at the sutures; wall subarenaceous, of calcareous particles with much calcareous cement, smooth; aperture crescentiform, opening at the base of the last septal face on the inner periphery. Diameter, 0.35 mm. to 0.8 mm.

Upper Glenn (surface outcrop), NW. ¼ of NW. ¼ of Sec. 18, T. 5 S., R. 2 E., Carter County, Oklahoma, about 2 miles south of Ardmore.

ENDOTHYRA CRASSA H. B. Brady

Plate 2, figs 6 *a–d*

Endothyra crassa H. B. BRADY, Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 97, pl. 5, figs. 15–17.

Test free, nautiloid more or less globular, slightly compressed, laterally nearly symmetrical; chambers numerous, broad, convex, embracing, usually ten in the last formed whorl; umbilici very inconspicuous; sutures indistinct, wall subarenaceous, smooth, aperture a crescentiform opening at the base of the last chamber.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

ENDOTHYRA ELEGANS Harlton, n. sp.

Plate 3, figs. 1 *a*, *b*

Test free, large, planispiral, involute, periphery acute and slightly rounded, non-umbilicated, chambers numerous, usually twenty, sutures very distinct, depressed; wall subarenaceous, of calcareous particles with much calcareous cement, smooth, aperture a curved slit at the base of the apertural face. Diameter, 1 mm. or more.

This form is related to *Endothyra radiata* and differs in the acute periphery, larger size of the test, and is non-umbilicated.

Upper Glenn, center of east line of SE. ¼ of Sec. 20, T. 5 S., R. 2 E. (surface outcrop), Carter County, Oklahoma, about 4 miles south of Ardmore. Holotype, U. S. National Museum, No. 71385.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES RECTUM (H. B. Brady)

Plate 3, figs. 2 *a–c*

Haplophragmium rectum H. B. BRADY, Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 66, pl. 8, figs. 8, 9.

Test free, relatively very small, early portions nautiloid, later portions elongate, crosier-shaped; chambers numerous, slightly inflated, spiral portion usually consisting of five visible chambers; linear portion long, straight, interior simple; sutures more or less depressed; peripheral margin rounded; wall arenaceous, smooth; aperture simple, terminal. Length, 0.4 mm. to 0.8 mm.

The specimen described by Brady resembles exactly the distorted forms found in the Mid-Continent region, with the spiral portion depressed, septa somewhat indistinct and the linear portion gradually increasing in diameter, as shown on Plate 2, fig. 2 *c*.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

AMMOBACULITES POWERSI Harlton, n. sp.

Plate 3, figs. 3 *a–e*

Test free, nautiloid in the young, in the ephebic stage crosier-shaped, slightly involute, umbilicated; chambers numerous, slightly inflated; early portion coiled in one plane, the later ones arranged in a straight linear series; interior simple; sutures somewhat depressed; peripheral margin broad and rounded; wall arenaceous, smooth; aperture simple, terminal. Length, 1 mm. to 2.0 mm.

The adult form of this species resembles *A. rectum* (H. B. Brady) but differs considerably in the larger and stouter size of the test.

Lower Glenn, SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ of Sec. 16, T. 6 S., R. 2 E. (surface outcrop), Love County, Oklahoma, about $8\frac{1}{2}$ miles south of Ardmore. Holotype, U. S. National Museum, No. 71398.

Genus STACHEIA H. B. Brady, 1876

STACHEIA PUPOIDES H. B. Brady

Plate 3, figs. 4 *a–h*

Stacheia pupoides, H. B. Brady, Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 115, pl. 8, figs. 17–27.

Test adherent, elongate, tapering, uniserial; chambers numerous, slightly inflated, each one partially embracing the preceding; chambers subdivided more or less regularly; wall arenaceous, smooth; aperture simple, terminal. Length, 1 mm.

The central part of *Stacheia pupoides* may have been a fragment of organic matter which has been entirely decomposed, in which case the margins of the chambers met and formed a nearly cylindrical test. Most of the specimens found in Texas, Oklahoma, and Kansas pertain to this category with their test thin and rather compressed. These appear to have lost all trace of the central support, except at the narrow end.

Lower Glenn, center of north line of Sec. 14, T. 5 S., R. 1 E. (surface outcrop), Carter County, Oklahoma, about 2 miles south of Ardmore.

STACHEIA CONGESTA H. B. Brady

Plate 3, figs. 5 *a, b*

Stacheia congesta, H. B. Brady, Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 117, pl. 9, figs. 1–5.

Test free or adherent, subcylindrical or irregular, elongate, chambers very numerous, irregular in shape, closely packed, confused in arrangement; wall granular or nearly smooth, composed of fine sand, loosely cemented at the surface, or various fine foreign materials; aperture more or less closed by foreign bodies. Length, 0.7 mm. to 3 mm.

The same observation noted under *Stacheia pupoides* may be made in regard to this species. Most specimens found in the Mid-Continent region appear to have lost all trace of the central support.

Upper Glenn, $\frac{1}{4}$ mile north of SE. cor. of Sec. 9, T. 6 S., R. 2 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

FAMILY TEXTULARIIDAE

Genus CRIBROSTOMUM Moeller, 1879

CRIBROSTOMUM JEFFERSONENSIS Harlton, n. sp.

Plate 4, figs. 1 *a*, *b*

Test free, elongate, tapering, slightly compressed; chambers few, usually ten, the later ones especially, broad and inflated, sutures depressed; wall finely arenaceous; aperture cribriform, circular, numerous, filled with material and somewhat obscured, appearing more like depressions or breaks, than like true apertures. Length, 0.6 mm. to 1.4 mm.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore. Holotype, U. S. National Museum, No. 71388.

CRIBROSTOMUM LUCILLEAE Harlton, n. sp.

Plate 4, figs. 2 *a–c*

Test free, large and stout, elongated, tapering; chambers biserial, inflated, usually twelve, last one broad, rounded, with flat apertural face; sutures deep, the later portion of test making a somewhat sinuate outline; wall arenaceous, smooth; aperture cribriform, usually with about ten pores. Length, 1.2 mm. to 1.8 mm.

The adult becomes uniserial as shown on Plate 3, fig. 2 *a*.

Upper Glenn, NW. ¼ of NW ¼ of NW. ¼ of Sec. 18, T. 5 S., R. 2 E. (surface outcrop), Carter County, Oklahoma, about 2 miles south of Ardmore. Holotype, U. S. National Museum, No. 71387.

Genus CLIMACAMMINA H. B. Brady, 1876

CLIMACAMMINA ANTIQUA H. B. Brady

Plate 4, figs. 3 *a–g*

Climacammina antiqua, H. B. Brady, Carbon. Foram. Pal. Soc., vol. 30, 1876, p. 68, pl. 2, figs. 1–9.

Test free, elongate, subcylindrical, compressed asymmetrical, gradually tapering at its biserial portion, earlier portion sometimes curved; uniserial chambers numerous, sometimes obliquely placed; sutures depressed; wall arenaceous, smooth; aperture cribriform. Length up to 2 mm.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

Genus TETRATAXIS Ehrenberg, 1843

TETRATAXIS CONICA Ehrenberg

Plate 4, figs. 5 *a–d*

Tetrataxis conica Ehrenberg, Ber. d. k. preuss. Akad. Wiss., 1843, p. 106.—Moeller, Mem. Acad. Imp. Sci. St. Petersbourg, ser. 7, vol. 27, No. 5, 1879, p. 71, pl. 2, figs. 3 *a–g*; pl. 7, figs. 1, 2; p. 72, fig. 30.

Valvulina paleotrochus H. B. Brady, Mem. Geol. Survey Scotland; Explan. Sheet 23, 1873, pp. 61, 95, etc.; H. B. Brady, Carbon. Foram. Pal. Soc., vol. 30, 1876, p. 83, pl. 4, figs. 1–4.

Test free or attached, conical, base flat, circular, slightly concave, or even convex, apical end more or less pointed, sometimes slightly rounded; chambers numerous, closely appressed, forming a triserial test; sutures depressed; wall finely arenaceous, smooth; aperture opening into the umbilicus, covered with a valvular flap. Diameter, 0.5 mm.

Upper Glenn, ¼ mile north of SE. cor. of Sec. 9, T. 5 S., R. 1 E. (surface outcrop), Carter County, Oklahoma, about 4 miles southwest of Ardmore.

TETRATAXIS CONICA, Ehrenberg, var. COMPRESSA, H. B. Brady

Valvulina paleotrochus, EHRENBERG, var. *compressa*, H. B. BRADY, Mem. Geol. Survey Scotland, Explan. Sheet 23, 1873, pp. 61, 95, etc.; Carbonif Foram. Pal. Soc., vol. 30, 1876, p. 85, pl. 4, figs. 5 *a*, *b*.

This species has the same general character as *Tetrataxis conica* and differs in the uneven, elongated, oval form; is one-sided at the base; deeply umbilicated on the inferior surface, and has stronger suture lines. Diameter, 0.5 mm.

Middle Glenn, SW. ¼ of SW. ¼ of Sec. 10, T. 6 S., R. 2 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

TETRATAXIS DECURRENS H. B. Brady

Plate 4, figs. 4 *a–c*

Valvulina decurrens H. B. BRADY, Mem. Geol. Survey Scotland, Explan. Sheet 23, 1873, pp. 63, 95, etc.; Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 87, pl. 3, figs. 17, 18.

Test free or attached, low conical depressed, sometimes a scale-like disc, base flat, concave, circular and thin, periphery sharp, irregular, sometimes upturned, apical end slightly rounded, sutures confused, oblique; chambers numerous, closely appressed; wall arenaceous, smooth; aperture opening into the umbilicus, covered with a valvular flap. Diameter, 1 mm. or more.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

Genus GLOBIVALVULINA Schubert

GLOBIVALVULINA BULLOIDES (H. B. Brady)

Plate 5, figs. 2 *a–c*

Valvulina bulloides H. B. BRADY, Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 89, pl. 4, figs. 12–15.

Test free, oblong, rounded; chambers few, inflated, subspherical, each succeeding one considerably larger than its predecessor, all visible from the peripheral side, three or four from below, inferior surface flat, or slightly concave, irregularly depressed at the umbilicus; wall calcareous, hyaline, smooth; aperture opening into the umbilicus. Diameter, 0.3 mm. to 0.5 mm.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 5 S., R. 1 E. (surface outcrop), Carter County, Oklahoma, about 8 miles south of Ardmore.

FAMILY LAGENIDAE

Genus ARCHEALAGENA Howchin, 1888

ARCHEALAGENA PARKERIANA (H. B. Brady)

Plate 5, figs. 3 *a–d*

Lagena parkeriana H. B. BRADY, Carbonif. Foram. Pal. Soc., vol. 30, 1876, p. 120, pl. 8, figs. 1–5.

Test free, monothalamous, globular, ovate or pyriform; wall calcareous, smooth, granular or even studded with minute irregular tubercles. Length, 0.5 mm.

Upper Glenn, SE. ¼ of SE. ¼ of SE. ¼ of Sec. 3, T. 6 S., R. 2 E. (surface outcrop), Love County, Oklahoma, about 6 miles south of Ardmore.

ARCHEALAGENA KANSASENSIS Harlton, n. sp.

Plate 5, fig. 4

Test free, monothalamous, elongate, pyriform, with long tapering neck; wall calcareous, hyaline, smooth; aperture small, rounded. Length, 0.6 mm.

Upper Glenn, SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore. Holotype, U. S. National Museum, No. 71395.

ARCHEALAGENA ADAENSIS Harlton, n. sp.

Plate 5, fig. 5

Test free, monothalamous, pyriform, subspherical, asymmetrical, usually slightly compressed; neck much produced; wall calcareous, smooth, well-defined perforations near the apertural end. Length, 0.8 mm.

Upper Caney (Lower Pennsylvanian), SW. ¼ of SW. ¼ of SW. ¼ of Sec. 25, T. 3 S., R. 1 E. (surface outcrop), Carter County, Oklahoma, about 5 miles north of Ardmore. Holotype, U. S. National Museum, No. 71393.

ARCHEALAGENA PLUMMERAE Harlton, n. sp.

Plate 5, fig. 6

Test free, flask-shaped, usually globular with a short neck; wall calcareous, smooth, finely perforate; aperture ectosolenian. Diameter, 0.4 mm.

Upper Glenn (surface outcrop), SW. ¼ of SW. ¼ of SE. ¼ of Sec. 19, T. 5 S., R. 2 E., Carter County, Oklahoma, about 4 miles south of Ardmore. Holotype, U. S. National Museum, No. 71394.

FAMILY GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA SEMINOLENSIS Harlton, n. sp.

Plate 5, figs. 7 *a, b*

Test free, subglobular, reticulate; chambers numerous, inflated, subspherical, all visible from above, seven visible from below, umbilicate, sutures deep; wall calcareous, hyaline, distinctly perforated; aperture of each chamber opens into a common umbilloid vestibule. Diameter, 0.8 mm.

This form has considerable resemblance to *Globigerina bulloides* d'Orbigny.

Upper Glenn, SW. ¼ of SW. ¼ of NW. ¼ of Sec. 20, T. 5 S., R. 1 E. (surface outcrop), Carter County, Oklahoma, about 4 miles north of Ardmore. Holotype, U. S. National Museum, No. 71380.

Genus ORBULINA d'Orbigny, 1839

ORBULINA? UNIVERSA? d'Orbigny

Plate 5, figs. 8 *a*, *b*

Test free, strongly reticulate, typically a single spherical chamber; wall calcareous, smooth, aperture a single large circular opening and smaller ones at the base of each reticulation.

Simpson formation (Ordovician), Mississippi lime, Fayetteville shale (Mississippian), Cherokee formation (Lower Pennsylvanian), etc.

There occur in the Ordovician, Mississippian, and Pennsylvanian numerous calcareous spherical bodies resembling a flattened *Orbulina universa* d'Orbigny, whose identification is doubtful. They are probably not Foraminifera.

FAMILY MILIOLIDAE

Genus CORNUSPIRA Schultze, 1854

CORNUSPIRA INVOLVENS (Reuss)

Plate 5, figs. 9 *a*, *b*

Operculina involvens Reuss, Denkschr. Akad. Wiss. Wien, vol. 1, 1849, p. 370, pl. 45, fig. 20.

Cornuspira involvens Reuss, Sitz. Akad. Wiss. Wien, vol. 48, 1863 (1864) p. 39, pl. 1, fig. 2.—Jones, Parker, and H. B. Brady, Pal. Soc., vol. 19, 1866, p. 3, pl. 3, figs. 52–54.—H. B. Brady, Rep. Voy. *Challenger*, Zoölogy, vol. 9, 1884, p. 200, pl. 11, figs. 1–3.—Balkwill and Millett, Jour. Micr., vol. 3, 1884, p. 23, pl. 1, fig. 1.—Balkwill and Wright, Trans. Roy. Irish Acad., vol. 28, 1885, p. 327, pl. 12, fig. 2.—H. B. Brady, Parker, and Jones, Trans. Zoöl. Soc., vol. 12, 1888; p. 216, pl. 40, figs. 1–3.—Sherborn and Chapman, Jour. Roy. Micr. Soc., 1889, p. 484, pl. 11, figs. 4, 5.—Egger, Abhandl. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 246, pl. 3, figs. 18, 19.—T. Rupert Jones, Pal. Soc., 1895, p. 128, pl. 3, figs. 52–54.—Morton, Proc. Portland Soc. Nat. Hist., vol. 2, 1897, p. 114.—Millett, Jour. Roy. Micr. Soc., 1898, p. 612.—Chapman, Jour. Linn. Soc., Zoölogy, vol. 30, 1907, p. 22, pl. 2, fig. 46.—Bagg, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 123.

Test free, discoidal, biconcave, spiral; whorls gradually increasing toward the last; peripheral margin round and broad, the inner margins partly overlapping the previous whorls; wall porcellaneous, imperforate; aperture formed by the open end of the tube. Diameter, 0.5 mm.

Upper Glenn, NW. ¼ of NW. ¼ of NW. ¼ of Sec. 12, T. 6 S., R. 1 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore.

FAMILY NUMMULITIDAE

Genus NUMMULOSTEGINA Schubert, 1907

NUMMULOSTEGINA ARDMORENSIS Harlton, n. sp.

Plate 5, figs. 10 *a–c*

Test free, planispiral, discoidal, bilaterally symmetrical, composed of 3–4 whorls; small umbo at the center of both sides; chambers numerous, usually more than twenty; sutures very distinct; periphery sharp; wall calcareous, smooth, finely perforate, aperture a simple V-shaped opening at the base of the last chamber.

Upper Glenn, ¼ mile north, SE. cor. of Sec. 9, T. 6 S., R. 2 E. (surface outcrop), Love County, Oklahoma, about 7 miles south of Ardmore. Holotype, U. S. National Museum, No. 71375.

EXPLANATION OF PLATES

Plate 1

Figs. 1 *a, b.—Hyperammina elongata* var. *clavatula* (Howchin), ×30. *a, b,* opposite views.

2 *a–e.—Ammodiscus incertus* (d'Orbigny), ×30. *a,* front view; *b,* apertural view; *c,* section; *d, e,* distorted specimens.

3 *a–h.—Lituotuba centrifuga* (H. B. Brady), ×30. *a,* front view; *b,* section; *c, d,* front views; *e–h,* distorted specimens.

4 *a–c.—Nodosinella glennensis* Harlton, n. sp., ×18. *a,* front view and apertural view; *b,* front view; *c,* section.

5 *a–e.—Nodosinella ardmorensis* Harlton, n. sp., ×30. *a,* front view; *b,* section; *c,* front view; *d, e,* distorted specimens.

Plate 2

Figs. 1 *a–c.—Bradyina holdenvillensis* Harlton, n. sp., ×30. *a,* front view; *b, c,* anterior and posterior views.

2 *a–c.—Endothyra radiata* H. B. Brady, ×30. *a, b,* opposite sides; *c,* apertural view.

3 *a–d.—Endothyra bowmani* Phillips, ×30. *a, b,* opposite sides; *c,* apertural view; *d,* section.

4 *a–c.—Endothyra ameradaensis* Harlton, n. sp., ×30. *a,* front view; *b,* apertural view; *d,* section.

5 *a, b.—Endothyra globula* d'Eichwald, ×50. *a,* front view; *b,* apertural view.

6 *a–d.—Endothyra crassa* H. B. Brady, ×30. *a,* front view; *b, c,* anterior and posterior views; *d,* section.

Plate 3

Figs. 1 *a, b.—Endothyra elegans* Harlton, n. sp., ×30. *a,* front view; *b,* apertural view.

2 *a–c.—Ammobaculites rectum* H. B. Brady, ×30. *a,* front view; *b,* section; *c,* distorted specimen.

3 *a–e.—Ammobaculites powersi* Harlton, n. sp., ×30. *a, b,* nepionic stage of development; *c–e,* ephebic stage of development.

4 *a–h.—Stacheia pupoides* H. B. Brady, ×30. *a–c,* front views; *d–h,* figures after H. B. Brady.

5 *a, b.—Stacheia congesta,* H. B. Brady, ×13. *a,* front view; *b,* section.

Plate 4

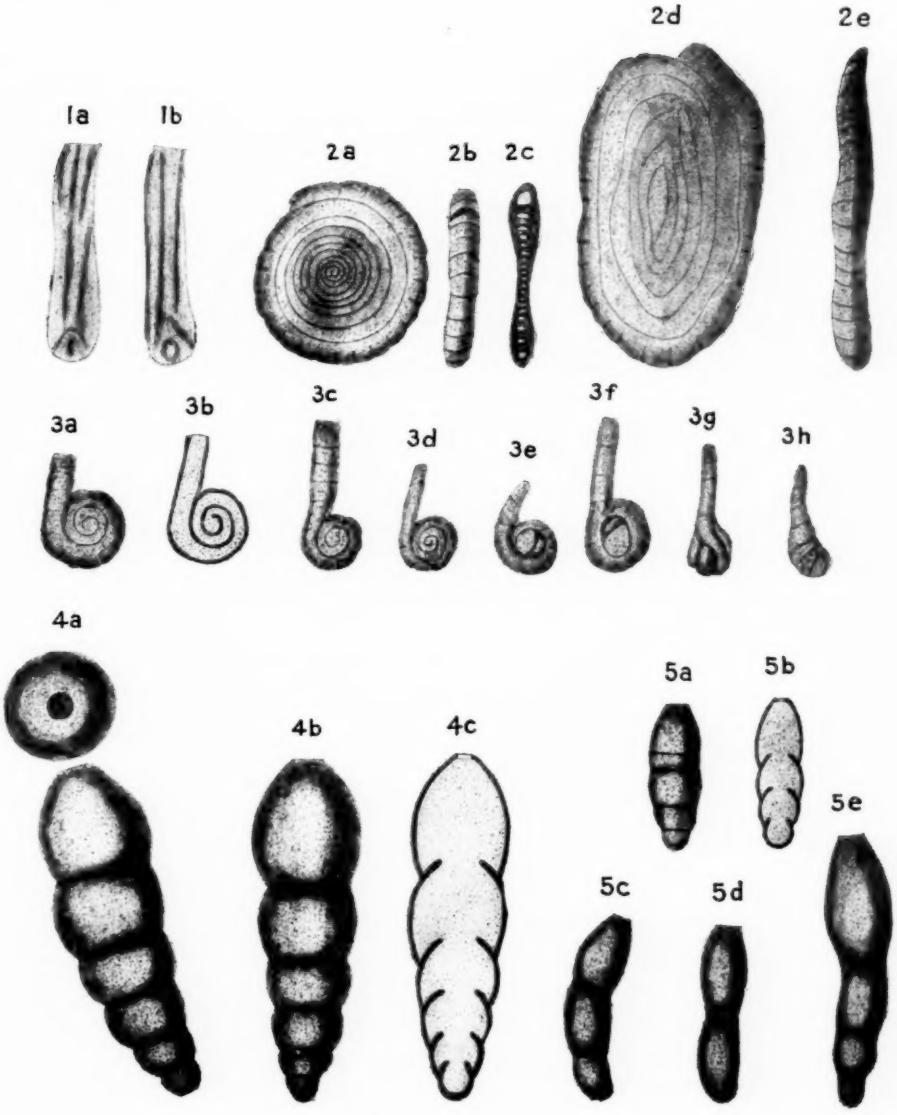
Figs. 1 *a, b.—Cribrostomum jeffersonensis* Harlton, n. sp., ×18. *a,* front view; *b,* apertural view.

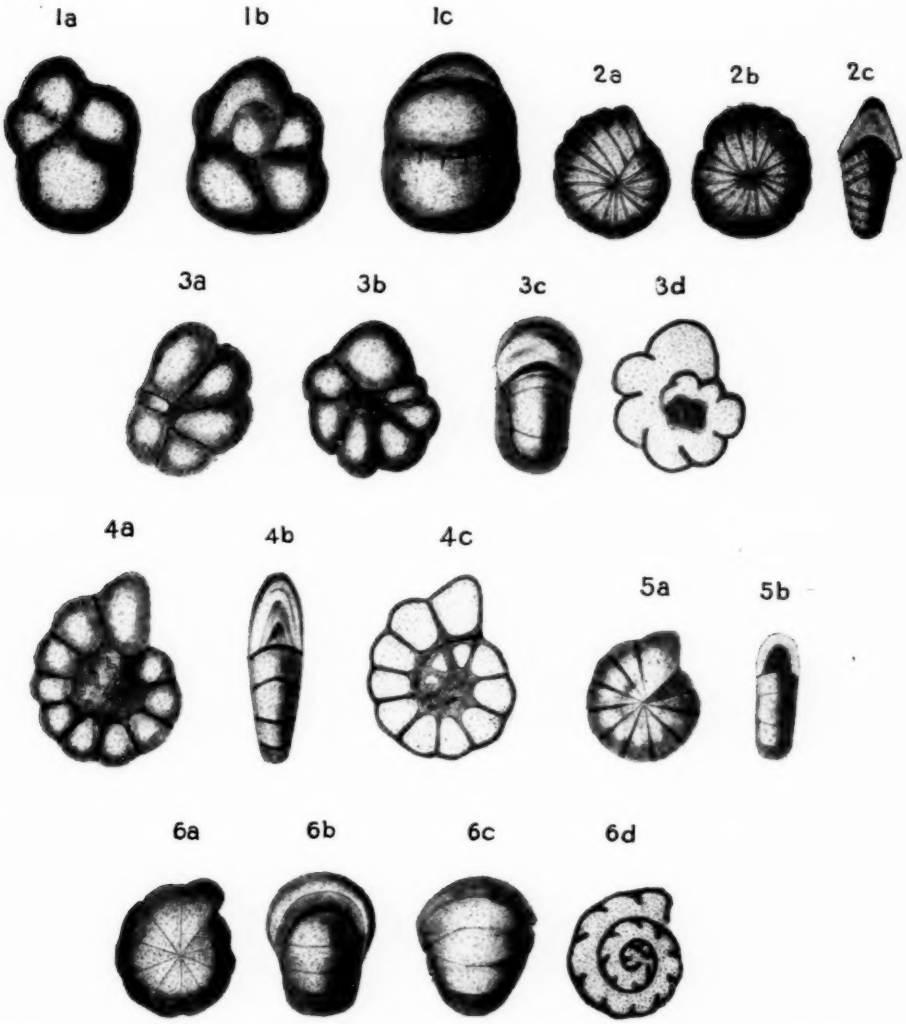
2 *a–c.—Cribrostomum lucilleae* Harlton, n. sp., ×18. *a,* front view; *b,* section; *c,* front view of nepionic form.

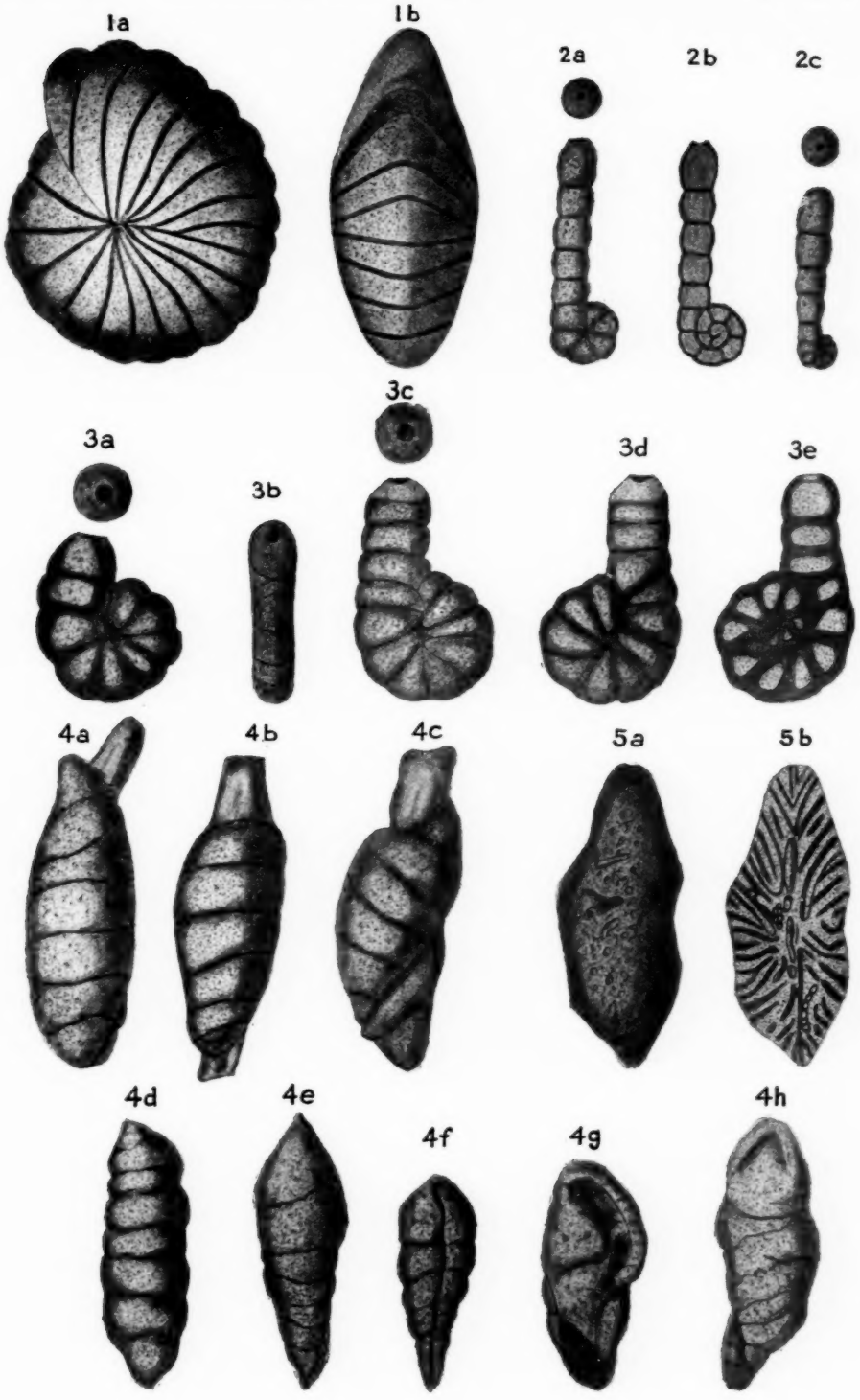
3 *a–g.—Climacammina antiqua* H. B. Brady, ×18. *a,* front view; *b,* section. *c–g,* distorted specimens.

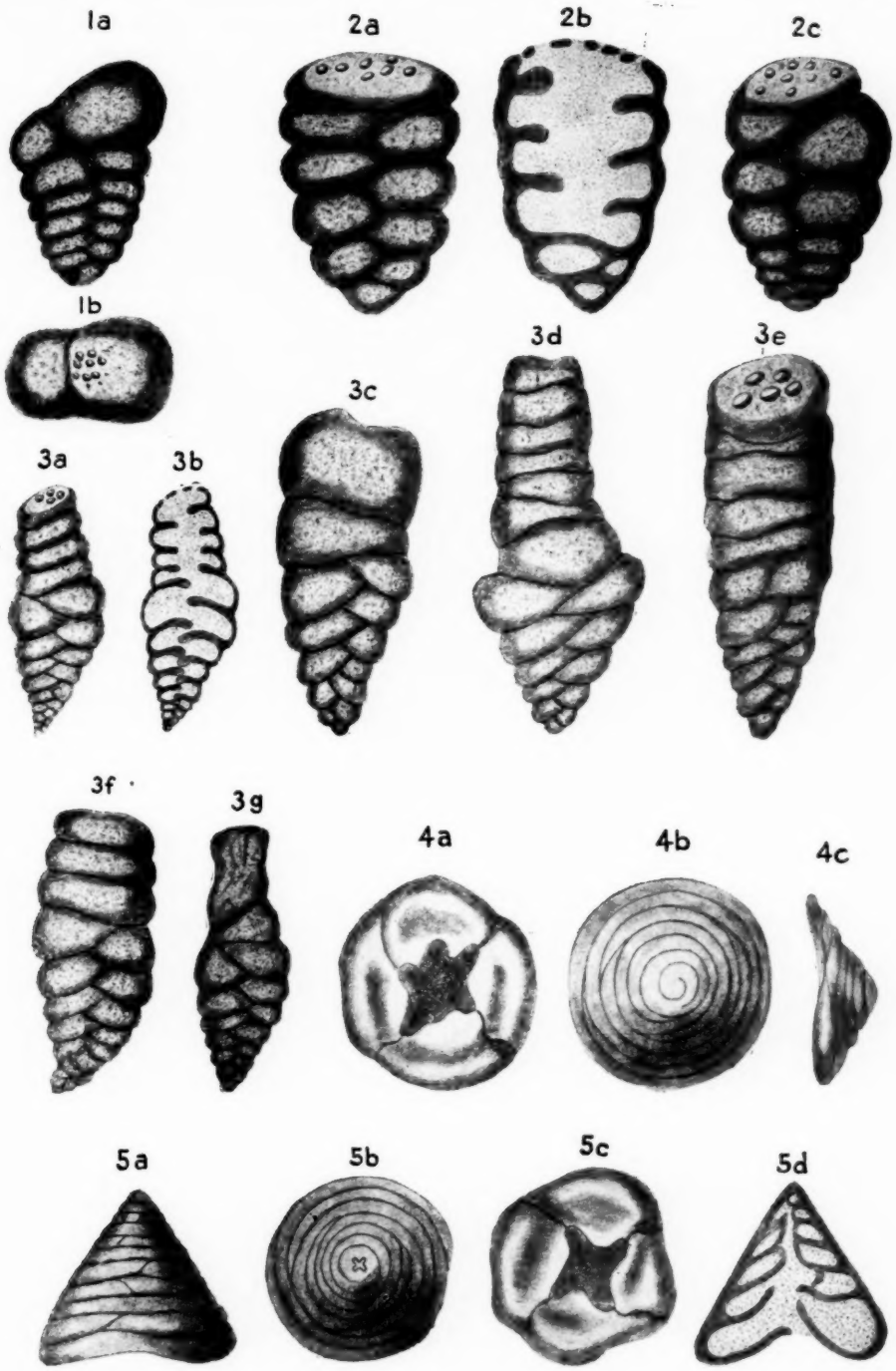
4 *a–c.—Tetrataxis decurrens* H. B. Brady, ×30. *a,* ventral view; *b,* dorsal view; *c,* side view.

5 *a–d.—Tetrataxis conica* Ehrenberg, ×30. *a,* side view; *b,* dorsal view; *c,* ventral view; *d,* section.


1a
1b
2a
2b
2c
2d
2e
3a
3b
3c
3d
3e
3f
3g
3h
4a
4b
4c
5a
5b
5c
5d
5e


1a
1b
1c
2a
2b
2c
3a
3b
3c
3d
4a
4b
4c
5a
5b
6a
6b
6c
6d


1a
1b
2a
2b
2c
3c
3a
3b
3d
3e
4a
4b
4c
5a
5b
4d
4e
4f
4g
4h


1a
2a
2b
2c
1b
3d
3e
3c
3a
3b
3f
3g
4a
4b
4c
5a
5b
5c
5d

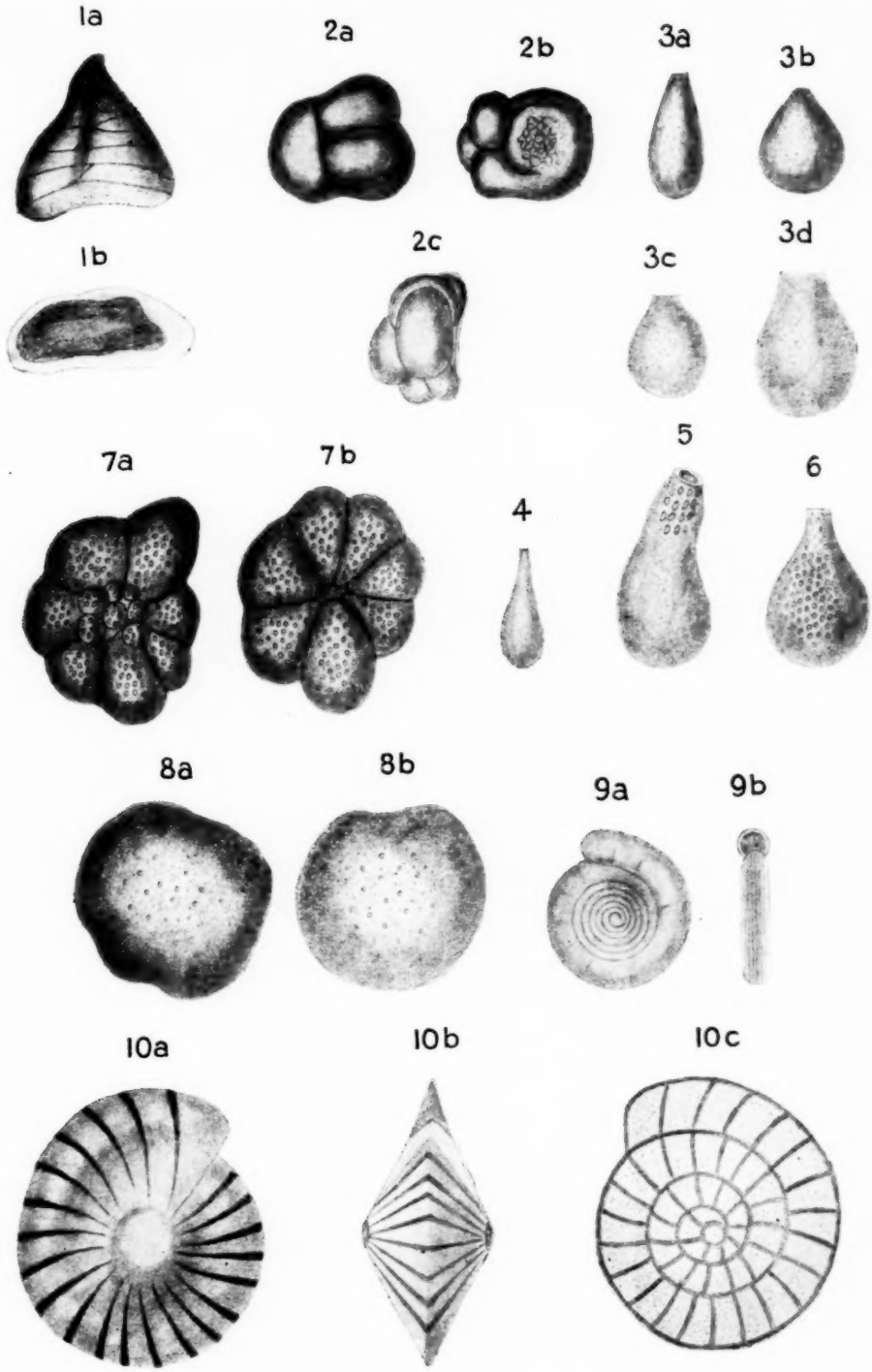

1a
2a
2b
3a
3b
1b
2c
3c
3d
7a
7b
4
5
6
8a
8b
9a
9b
10a
10b
10c

PLATE 5

FIGS. 1 *a, b.—Tetrataxis conica* Ehrenberg, var. *compressa* (H. B. Brady), ×30. *a*, side view; *b*, ventral view.

2 *a–c.—Globivalvulina bulloides* (H. B. Brady) after H. B. Brady, ×33.3. *a*, dorsal view; *b*, ventral view; *c*, side view.

3 *a–d.—Archealagena parkeriana* (H. B. Brady), ×30. *a–d*, front views;

4. *Archealagena kansasensis* Harlton, n. sp., ×30.

5. *Archealagena adaensis* Harlton, n. sp., ×30.

6. *Archealagena plummerae* Harlton, n. sp., ×30.

7 *a, b.—Globigerina seminolensis* Harlton, n. sp., ×30. *a*, dorsal view; *b*, ventral view.

8 *a, b.—Orbulina? universa?* d'Orbigny, ×30. *a, b*, opposite views.

9 *a, b.—Cornuspira involvens* (Reuss), ×30. *a*, front view; *b*, apertural view.

10 *a–c.—Nummulostegina ardmorensis* Harlton, n. sp., ×30. *a*, front view; *b*, apertural view; *c*, section.

THE STRATIGRAPHIC RANGE OF THE CRETACEOUS OSTRACOD BAIRDIA SUBDELTOIDEA AND ITS ALLIES

C. I. ALEXANDER
Princeton University

ABSTRACT

Bairdia subdeltoidea (Münster), a conspicuous and fairly abundant ostracod species which has been described by various authors as extending through the entire Upper Cretaceous and Tertiary, is shown to be divisible into a number of distinct species and varieties. Two new species, *Bairdia obliqua* and *Bairdia magna*, and one new variety, *Bairdia subdeltoidea* var. *rotunda*, are described, and the stratigraphic range of each is noted.

Among the Ostracoda there are at present many so-called "species," each of which really includes a number of closely related, but distinct, forms. Such "species" are described as having a long time-range and as being of no value in exact correlation. It usually happens that a careful study of the different forms included in these "species" enables the micropaleontologist to recognize several easily identifiable varieties or even separate species, with short ranges, that can safely be used in making close determinations of the age of the beds in which they occur. While engaged in the preparation of a paper, not yet completed, on the Cretaceous Ostracoda of North Texas, the writer has had occasion to work with one of these compound "species," *Bairdia subdeltoidea* (Münster), which seems to deserve to be split without further delay.

Anyone who has worked on the microfossils of the North Texas Cretaceous sediments must have been impressed with the abundance of the ostracods in washings of marl, clay, and shale samples, and with their potentialities as horizon-markers. Not only are the various species important locally as guide fossils, but, as the writer will demonstrate in the uncompleted work referred to above, they may also be used to correlate formations over wide areas, even on separate continents. Many species reported from such widely separated regions as Europe, South Africa, and Australia also occur commonly in beds of the same age in the Cretaceous of Texas. The various Upper Cretaceous and Tertiary forms which have been described under the name *Bairdia subdeltoidea* have been recorded principally, if not entirely, from England, Belgium, Germany, and Bohemia.

One of the purposes of the present paper is to show the age and value as index fossils of the various forms into which this old "species" is here divided.

The materials for the writer's studies have been collected over wide areas in the Texas Cretaceous, from the Red River on the north to the region of Austin on the south. Much valuable material has been secured from a series of cores from wells drilled by the engineers of the Tarrant County (Texas) Water Improvement

District No. 1. The writer had the opportunity of subjecting these cores to the minutest study under the helpful supervision of Professor W. M. Winton, of the department of geology and biology of Texas Christian University. Thanks are also due to Mr. W. L. Moreman, of the same department, for some excellent material from the Eagleford formation.

T. R. Jones,[1] in his monograph on the Tertiary Entomostraca, describes the occurrence of *Bairdia subdeltoidea* in the Cretaceous and Tertiary sediments, and states, conservatively enough, that with such wide distribution there is, of course, much variation; but he does not attempt any splitting of the species.

In a later paper[2] he quotes G. S. Brady as saying in his report on the Ostracoda for the *Challenger Report*, that ". . . . it is very probable that several species are composed under the name *subdeltoidea*, as applied by various paleontologists. . . ."

The species is further described by Joseph Kafka[3] as occurring from "the lower Cenomanian on into the Senonian, and even further, throughout the entire Tertiary up to the Pliocene."

The Woodbine sand of the Texas Cretaceous, which Dr. Gayle Scott[4] has shown conclusively to be the equivalent of the European Cenomanian, is unproductive of fossil remains with the exception of plants. Hence we do not know whether *Bairdia subdeltoidea* lived in the North Texas region during Cenomanian time or not. However, the species does occur in the immediately overlying Eagleford formation and throughout the remainder of the Upper Cretaceous.

The "species" probably ranges through the following North Texas formations, listed from above downward:

Navarro Clay
Taylor Marl
Austin Chalk?
Eagleford Shale
Woodbine Sand?

It has actually been found in the Navarro, Taylor, and Eagleford. It doubtless occurs in the Austin chalk; but from the scattered marly layers of this massive limestone formation the writer has been able to obtain only a few very unsatisfactory samples, in none of which could he discover any examples of this species. Its absence from these samples, however, is certainly not to be taken as evidence of its non-existence in the waters in which the Austin chalk was laid down.

Thus it seems likely that "*Bairdia subdeltoidea's*" range in North Texas is coextensive with its range in the European Cretaceous, since Dr. Gayle Scott[5] has

[1] "Monograph of the Tertiary Entomostraca of England," *Pal. Soc. Monograph*, 1856, p. 53.

[2] Jones and Hinde, "Supplementary Monograph of the Cretaceous Entomostraca of England and Ireland," *Pal. Soc. Monograph*, 1890, p. 7.

[3] "Ostracoda," in Fritch's *Die Crustaceen der böhmischen Kreideformation*, 1887, p. 13.

[4] *Études Stratigraphiques et Paléontologiques sur les Terrains Crétacés du Texas* (These Doctorat, Grenoble, 1926), p. 97; "On a New Correlation of the Texas Cretaceous," *Amer. Jour. Sci.*, Vol. 12 (1926), p. 160.

[5] *Études Stratigraphiques et Paléontologiques sur les Terrains Crétacés du Texas* (These Doctorat, Grenoble, 1926), pp. 96–113; "On a New Correlation of the Texas Cretaceous," *Amer. Jour. Sci.*, Vol. 12 (1926), p. 157.

shown that the five formations listed above are equivalent in age to the European Cenomanian, Turonian, and Senonian, up to and including the lower Maestrichtian. On the other hand, numerous tests have demonstrated that the various Upper Cretaceous formations in which *Bairdia subdeltoidea* has been found can be recognized on the basis of variations within this so-called "species." Since these variations are so obvious as to require only the most cursory examination for their recognition, and since the separate species and varieties involved are of distinct stratigraphic importance, a splitting of the original "species" seems justified.

Further and more detailed work will doubtless narrow the range within the formations in which they occur, of the various species and varieties described below.

The original name, *Bairdia subdeltoidea* (Münster), will be retained for the Eagleford species, which resembles more closely than any of the others the original figures. One new variety from the Taylor formation and two new species, one from the Taylor and another from the Navarro, are described below.

BAIRDIA SUBDELTOIDEA (Münster)

Plate 6, figs. 2, 4

Cythere subdeltoidea MÜNSTER, Jahrb. Min., Geog., etc., 1830, p. 64.
Cytherina subdeltoidea RÖMER, Neues Jahrb. Min., Geog., etc., 1838, p. 517, plate 6, fig. 16.
Cythere trigona BOSQUET, Mem. Soc. Roy. Sci., Liege, vol. 4, 1847, p. 358, plate 1, fig. 3.
Bairdia subdeltoidea JONES, Mono. Cret. Entom., Pal. Soc. Mono., 1849, p. 23, plate 5, fig. 15.

Carapace in side view, sub-triangular; height equal to about two-thirds of length. Greatest height of carapace at about middle. Valves strongly and evenly convex, smooth or minutely punctate; in well-preserved specimens, striated marginal areas are visible anteriorly and posteriorly. Dorsal margin strongly arched, obscurely angled at highest point. Ventral margin convex. Anterior end obliquely rounded, obscurely angled at middle. Posterior end produced into short, sub-acute beak. Left valve the larger, overlapping right valve, especially strongly along anterior and posterior one-thirds of the dorsal margin, and along the middle of the ventral margin. Length, 1.05 mm.; height, 0.67 mm. Plesiotypes in the Princeton University Paleontological Collections, Nos. 9000, 9001, and 9002.

This form, which may be called the typical *Bairdia subdeltoidea*, has been found in North Texas, only in the Upper Cretaceous Eagleford formation.

BAIRDIA SUBDELTOIDEA, var. ROTUNDA, n. var.

Plate 6, figs. 1, 2

Bairdia subdeltoidea, of authors, in part.

Carapace in side view sub-triangular; height equal to about two-thirds of length. Greatest height of carapace at about middle. Valves strongly and evenly convex; surface smooth or minutely punctate; marginal striations in well-preserved individuals. Dorsal margin strongly and evenly arched, obscurely angled at highest point. Ventral margin convex. Anterior end broadly and evenly rounded. Posterior end sub-acute. Left valve larger, overlapping right valve as in typical form of the species, described above. Length, 1.17 mm.; height, 0.80 mm. Holo-

type No. 9003 and paratype No. 9004 in the Paleontological Collections of Princeton University.

This variety differs from the typical form of *Bairdia subdeltoidea* mainly in the contour of the anterior end. In the present form it is broadly and almost perfectly evenly rounded; while in the typical form it is obliquely rounded and indistinctly angled near the middle of the margin. It may also be noted that the dorsal margin is more perfectly arched and the posterior margin less produced, in this new variety than in the typical examples of the species.

Bairdia subdeltoidea, var. *rotunda* occurs fairly commonly in the Taylor formation of the Upper Cretaceous of Texas.

BAIRDIA OBLIQUA, n. sp.

Plate 6, fig. 6

Bairdia subdeltoidea, of authors, in part.

Carapace in side view sub-triangular; height slightly less than two-thirds of length. Greatest height of shell distinctly posterior to middle. Dorsal margin strongly and unevenly arched, sloping much more steeply toward the posterior than toward the anterior extremity. Ventral margin convex. Anterior end obliquely rounded. Posterior margin produced into blunt, beak-like projection. Larger left valve overlapping right valve, especially strongly along anterior half of dorsal margin. Length, 0.9 mm.; height, 0.57 mm. Holotype No. 9005 in Paleontological Collections of Princeton University.

This species differs from the typical *Bairdia subdeltoidea* in the proportionately lesser height of the carapace, in the marked posterior position of the highest point of the arch of the dorsal margin, in the decidedly more acute posterior end, and in the peculiar overlap of the larger left valve.

The species is rare and has been found only in the Taylor formation of the Upper Cretaceous of Texas.

BAIRDIA MAGNA, n. sp.

Plate 6, figs. 7, 8

Bairdia subdeltoidea, of authors, in part.

Carapace in side view sub-triangular; height equal to about two-thirds of length. Greatest height at about middle. Valves strongly and evenly convex; surface smooth or minutely punctate. Dorsal margin strongly and evenly arched. Ventral margin convex. Anterior end broadly and evenly rounded. Posterior end obtusely angled. Left valve larger, overlapping the smaller right valve, especially strongly along the anterior and posterior one-thirds of the dorsal margin, and along the middle of the ventral margin. Length, 1.4 mm.; height, 0.92 mm. Holotype No. 9006 and paratype No. 9007 in the Paleontological Collections of Princeton University.

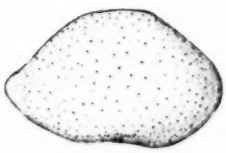
Bairdia magna is easily differentiated from any of the preceding species or varieties on the basis of size alone. That the greater size of this species from the Navarro is a constant character, and not merely an individual variation, is indi-

1

2

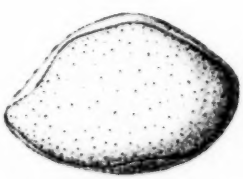
3

4

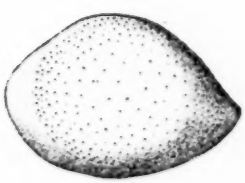


5

6



7



8

cated by the fact that 90 per cent of the specimens referred to it measure from 1.3 mm. to 1.5 mm. in length, while the examples of the preceding forms reach their maximum length at only about 1.1 mm. and are usually considerably smaller than that. Young specimens of *Bairdia magna* may be readily recognized on the basis of characters other than size. This species most closely resembles *Bairdia subdeltoidea*, var. *rotunda*, from which it may be differentiated by the evenly and broadly rounded dorsal margin and by the somewhat blunter posterior end.

Bairdia magna occurs as a fairly common member of the microfauna of the Navarro formation of the Upper Cretaceous of Texas.

EXPLANATION OF PLATE 6

FIG. 1.—*Bairdia subdeltoidea*, var. *rotunda*, left valve, ×21.
2.—*Bairdia subdeltoidea* (Münster), left valve, ×21.
3.—*Bairdia subdeltoidea*, var. *rotunda*, entire specimen viewed from right side, ×21.
4.—*Bairdia subdeltoidea* (Münster), right valve, ×21.
5.—*Bairdia magna*, right valve, ×21.
6.—*Bairdia obliqua*, entire specimen, viewed from right side, ×21.
7.—*Bairdia magna*, entire specimen, viewed from right side, ×21.
8.—*Bairdia magna*, left valve, ×21.

PLEISTOCENE FORAMINIFERA FROM THE LOMITA QUARRY, PALOS VERDES HILLS, CALIFORNIA

J. J. GALLOWAY AND STANLEY G. WISSLER
New York, New York, and Los Angeles, California

ABSTRACT

The Lomita Quarry in the Palos Verdes Hills of southern California contains the best deposit of Foraminifera known on the North American continent in the amount and accessibility of the material. From this deposit are here described and figured 79 species of Foraminifera, 41 of which are new, and 1 new genus. The age of the deposit is Lower San Pedro, Pleistocene.

A quarry has been opened in the north side of the Palos Verdes Hills, about 20 miles south of Los Angeles, California and 2 miles south of the town of Lomita; and from it a soft limestone is taken for use as fertilizer and chicken feed. The quarry is known as the "Decomposed Marine Shell and Bone Quarry," and is owned by the Lomita Lime and Fertilizer Company. It is frequently referred to as the "Lomita Quarry."

The Quarry is about 200 feet long north and south and about 30 feet deep. The rock quarried is a fine-grained, soft coquina, composed of broken shells of gastropods and pelecypods and beds of Foraminifera and glauconite. Some whale and other vertebrate bones have been found in the coquina. The limestone is unconformably overlain by quartz sand and gravel and overlies unconformably clay shale of lower Pliocene age.

The limestone beds dip to the south from 10° to 25° and are faulted with numerous faults 2–6 feet apart. The faults dip to the north 35° to 40°. The displacement varies from a few inches to 4 feet and is upward on the south side of each fault, so that the same beds are only about 10 feet lower at the south end of the Quarry than they are at the north end. The sand beds lying above dip to the north about 10°, and the underlying shale dips to the south about 45°.

The stratigraphic section, from the top down, is shown in Table I.

The limestone at the Lomita Quarry is Pleistocene in age, being the lower member of the San Pedro group. It is overlain unconformably by Pleistocene sands and gravels, which contain no fossils. At the Quarry the limestone lies unconformably on the lower Pico formation of the lower Pliocene. The Quarry beds are later than the Saugus, Upper Pliocene foraminiferal marls at Timms Point, San Pedro. The faunas at the two places are similar, but differ considerably in species and abundance of the same species. The Lomita Quarry Foraminifera are much like those found in the Pleistocene at Santa Barbara, California.

The lowest, thick bed of coquina contains boulders of clay, still wet and un-

lithified, which contain Miocene Foraminifera, different boulders having different Miocene faunas.

The shale lying unconformably below the coquina and exposed in a ravine at the north end of the Quarry is Lower Pico of the Lower Pliocene in age, and contains a large foraminiferal fauna like that found in the Lower Pico in well samples in the Los Angeles Basin. That fauna is now being described by us for publication.

The best foraminiferal bed is the one designated above as the "lower bed," which consists of about 90 per cent Foraminifera, 5 per cent molluscan fragments, and 5 per cent glauconite grains. The bed is greenish buff in color with a texture about that of medium-grained sand. The "middle" and "upper" beds contain more glauconite and fragments of shells and are somewhat more cemented. Foraminifera occur abundantly also in the coquina, but on account of those beds being more

TABLE I

	Feet
Coarse quartz sand and boulders	20
Unconformity	
Fine grained coquina with streaks composed of Foraminifera and glauconite, consolidated	5
Foraminifera and glauconite, uncemented	1
Coquina with streaks composed of Foraminifera	10
Foraminifera and glauconite, "Upper bed"	1
Coquina and small molluscs, consolidated	4
Foraminifera, coquina with much glauconite and small molluscs, "Middle bed"	4
Coquina, consolidated	6
Foraminifera, nearly pure and little consolidated "Lower bed"	2
Coquina with chert pebbles	12
Coquina with mud boulders and pebbles of chert and basalt	30
Unconformity	
Soft clay shale with Foraminifera (Lower Pico)	100+

cemented the Foraminifera cannot be readily extracted. In the three main foraminiferal beds the specimens are well preserved; but on account of water percolating through the rock they have more or less lost the hyaline condition they originally had.

The three main foraminiferal beds constitute the largest and best deposit of Foraminifera that we know of in North America. The Foraminifera consist in large part of specimens of *Globigerina* and *Cassidulina*, but *Bolivina* and *Themeon* also occur abundantly, and other forms in smaller numbers. We have described in this paper 79 species and varieties, belonging to 32 genera. There are 41 new species and 1 new genus. The large number of new species is due partly to the fact that very few Pleistocene faunas have ever been described and partly to the fact that several of the species have been found in Recent or other deposits and misidentified. Several other species occur rarely which could not be included in this paper.

The species have been compared carefully with species described and figured in nearly all of the important literature on Foraminifera, and with similar Recent

and fossil specimens. In the matter of names, the International Rules of Zoölogical Nomenclature have been carefully adhered to.

The figures were all drawn with camera lucida by the authors and were shaded by professional artists.

Our attention was first called to the Lomita Quarry Foraminifera by Mr. D. D. Hughes, of Los Angeles, who sent us some of the material in 1924 as a test of the reliability of Foraminifera in age determination. The age determined at that time was Pleistocene, which agrees with the evidence from stratigraphic relations, structure, Mollusca and vertebrates.

We wish to acknowledge assistance received in preliminary identifications from Mr. Corbin D. Fletcher, Mr. G. H. Doane, and Miss Margaret Hitchcock.

Systematic Part

Family SPIRILLINIDAE Rhumbler, 1895

Genus SPIRILLINA Ehrenberg, 1843

Genotype (monotypical) *S. vivipara* Ehrenberg, Abh. k. Ak. Wiss. Berlin, Phys.-Math. Cl., for 1841, 1843, p. 422, pl. 3, pt. 7, fig. 41. (Recent, Vera Cruz, Mexico.)—H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 629.—Rhumbler, Nachr. Königl. Gesell. Wiss. Göttingen, Math.-Phys. Kl., 1895, p. 85; Foram. Plankton-Exped., pt. 2, 1913, p. 388.—Chapman, Foraminifera, 1902, p. 215.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 2.—Sollas, Quart. Jour. Geol. Soc., vol. 77, 1921, p. 207.

Description.—Test free or lightly attached to plants; planispiral, one side more concave than the other, consisting of a single non-septate chamber; whorls only slightly involute; wall hyaline, apparently finely or coarsely perforate, frequently with thickening tissue in the form of knobs, limbate sutures between whorls, a carina or otherwise; edge of the test smooth and round or with one or two carinae; aperture simple, crescentiform or slightly modified, at the end of the chamber. Sollas says the wall is not truly perforate, but the pores end in pouch-like vesicles, calling them "pseudopores."

SPIRILLINA VIVIPARA Ehrenberg

Plate 7, fig. 1

Spirillina vivipara Ehrenberg, Abh. Ak. Wiss. Berlin, 1841, p. 442, pl. 3, fig. 41.—Parker and Jones, Phil. Trans., vol. 155, 1865, p. 397, pl. 15, fig. 28.—H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 630, pl. 85, figs. 1–5.—Flint, Rep. U. S. Nat. Mus., 1897 (1899), p. 326, pl. 71, fig. 4.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 3, pl. 1, figs. 1, 2.

Description.—Test monothalamous, planispirally coiled in six or seven closely appressed volutions which gradually increase in width, periphery rounded, sides flattened or somewhat concave; sutures very slightly depressed but conspicuous; wall hyaline, smooth, with conspicuous, scattered perforations; aperture small, crescentic.

Diameter of the figured specimen, 0.9 mm.

Occurrence.—A single specimen of this species was found in the upper bed at the D. M. S. & B. Quarry. It is a poorly preserved plano-convex form with a calci-

fied wall which obscures the pores and the aperture. We have not found this form in the other two beds nor in the Timms Point Pliocene material which we have examined. Various authors have described it from the Recent oceans.

Family MILIOLIDAE d'Orbigny, 1846

Genus QUINQUELOCULINA d'Orbigny, 1826

Genotype (designated by Cushman, 1917) *Serpula seminulum* LINNÉ, Syst. Nat., ed. 12, 1767, p. 1264; 13th (Gmelin's) ed., 1788, p. 3739, from Plancus, De Conchis Minus Notis, 1739, p. 19, pl. 2, fig. 1. (Recent, Adriatic at Rimini.) *Quinqueloculina* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 303.—SCHLUMBERGER, Mém. Soc. Zoöl. France, vol. 6, 1893, p. 65.—CUSHMAN, U.S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 42.

Miliolina (part) WILLIAMSON, Rec. Foram. Great Britain, 1858, p. 85, pl. 7, figs. 183–85.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 156.—JONES, Pal. Soc. Mono., Crag, 1895, p. 116.—CHAPMAN, Foraminifera, 1902, p. 90.

Description.—Test free; the nucleoconch in the microspheric form consists of an oval proloculum and one or two chambers a coil or less in length, and in the megaspheric form of a larger proloculum and one chamber less than one coil in length; the nucleoconch in both the microspheric and megaspheric forms is followed by chambers one-half a coil in length, wound lengthwise about an elongate axis, and spirally transverse to the elongate axis where successive chambers are 144° apart, so that five chambers make two complete whorls and every fifth chamber is radially superimposed on another, adjacent chambers being 72° apart; four chambers are visible from one side of the test and three from the other; wall porcellaneous, smooth or variously ornamented or covered with sand grains, but with very little thickening tissue inside (differing from *Miliola*); aperture flush with the surface or with neck, round or elongate, with plate-like or bifid tooth; the aperture alternates from end to end of the test.

Quinqueloculina was included by Williamson, Carpenter, Parker, Jones, Brady, Chapman and others in Williamson's composite genus *Miliolina*, which is a synonym of *Triloculina*.

QUINQUELOCULINA AKNERIANA d'Orbigny

Plate 7, fig. 3

Quinqueloculina akneriana D'ORBIGNY, Foram. Foss. Vienne, 1846, pl. 18, figs. 16–21.

Miliola (*Quinqueloculina*) *seminulum* PARKER and JONES (part, not Linné), Phil. Trans. Roy. Soc. London, vol. 155, 1865, p. 410, pl. 15, fig. 35 (not pl. 17, fig. 87).

Miliolina seminulum (Linné), H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 157, pl. 5, fig. 6.

Description.—Test ovate in side view, subtriangular in end view, periphery bluntly rounded; chambers clearly marked, with only a very small portion of the fourth showing on the more convex side of the test; wall smooth, porcellaneous, imperforate; aperture nearly round, not produced, with a simple plate-like tooth.

Length of the figured specimen, 0.38 mm.; width, 0.30 mm.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Abundant in

the Pliocene at Timms Point, San Pedro, California. Abundant in well samples from the Saugus of the Los Angeles Basin.

This form is usually referred by most authors to *Quinqueloculina seminulum* (Linné), (Syst. Nat., 12th ed., 1767, p. 1264, No. 791; 1788, 13th (Gmelin's) ed., p. 3739, No. 2), but it is very doubtful that it is the species named by Linné. It is, however, very similar to *Quinqueloculina akneriana* d'Orbigny. This species approachss very closely to the triloculine stage in the evolution of the Miliolidae. The figured specimen is from the upper bed at the D. M. S. & B. Quarry.

Genus SIGMOILINA Schlumberger, 1887

Genotype (first species, designated by Cushman, 1917) *Planispirina sigmoidea* H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 197, pl. 2, figs. 1–3. (Recent, off Sombrero Island, West Indies.) *Sigmoilina* SCHLUMBERGER, Bull. Soc. Zoöl. France, vol. 12, 1887, p. 488, text figs. 1–5.—CHAPMAN, Foraminifera, 1902, p. 93.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 61.

Description.—Test free, elliptical, unequally biconvex; chambers numerous, two to a whorl in the adult, early chambers arranged as in *Quinqueloculina*, later chambers half a coil in length and added in planes more than 180° apart, which gives a gradual turning about the elongate axis making a sigmoid curve; each chamber in the type species has alar projections nearly covering the previous chamber; wall porcellaneous, smooth or covered with sand grains; aperture single, round, with or without a simple or bifid tooth.

SIGMOILINA ELLIPTICA, n. sp.

Plate 7, fig. 2

Description.—Test elliptical in side view; chambers long, tubular, of nearly even diameter from end to end, scarcely overlapping, five visible on each side of the test; sutures slightly depressed; wall smooth; aperture produced, round, no tooth observed.

Length of type specimen, 0.4 mm.

Holotype.—Columbia University Paleo. Coll. No. 19854, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Very rare in the lower bed at the D. M. S. & B. Quarry and in the Timms Point Pliocene. Rare in well samples from the Saugus and Lower Pico of the Los Angeles Basin.

This is probably the form identified by Bagg from the Pleistocene of Santa Barbara (U. S. G. S. Bull. 513, 1912, p. 33) as *Sigmoilina tenuis* (Czjzek). *S. tenuis* has several whorls of chambers in the same plane, as in *Massilina*.

Family GLOBIGERINIDAE Carpenter, 1862

Genus GLOBIGERINA d'Orbigny, 1826

Genotype (first species, designated by Parker, Jones and Brady, 1865) *G. bulloides* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 277, Model No. 76; in Cuvier, Animal Kingdom, Henderson's ed., vol. 3, 1834, p. 18, plates 1837, pl. 3, fig. 12. (Recent, Adriatic Sea, near Rimini.)—PARKER, JONES and BRADY, Ann. Mag. Nat. Hist., ser. 3, vol. 16, 1865, p. 36.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 589.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 5; Bull. 104, pt. 5, 1924, p. 5.

Description.—Test free, trochoid, at least in the young; chambers moderate in number (two to twenty), globular, not closely appressed; walls finely to coarsely perforate (.002–.01 mm.), reticulate or papillose, with the pores at the base of depressions; aperture large, simple, opening usually into the umbilicus, frequently with accessory apertures on the top of the spire. Ornamentation practically lacking, except for minute spines in well-preserved, Recent specimens. The adult portion of the test is frequently degenerate in manner of coiling, shape of chambers, size of perforations, etc. In the megaspheric form the early chambers are omitted.

GLOBIGERINA APERTURA Cushman

Plate 7, fig. 5

Globigerina apertura Cushman, U. S. G. S. Bull. 676, 1918, p. 57, pl. 12, fig. 8.

Description.—Test composed of about ten regularly and rapidly enlarging, nearly spherical chambers arranged in a low spire with four forming the last volution; sutures deeply depressed; wall reticulate; aperture very large, nearly circular, opening into the umbilicus in which the apertures of the preceding chambers are likewise visible, provided with a slight lip.

Length of the figured specimen, 0.45 mm.; width, 0.37 mm.

Occurrence.—Abundant in all three beds at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material examined. Rare in well samples from the Fernando of the Los Angeles Basin. Cushman's type is from the Miocene of the Atlantic Coast.

This species is characterized by its large aperture in which character, in addition to its shorter test, it differs from *G. bulloides* d'Orbigny. The figured specimen is from the lower bed at the D. M. S. & B. Quarry.

GLOBIGERINA BULLOIDES d'Orbigny

Plate 7, fig. 4

Globigerina bulloides D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 277, No. 1; Modèles, No. 17 and No. 76; Foram. Voy. Amér. Mérid., 1839, p. 37; in Barker, Webb and Berthelot, Hist. Nat. Îles Canaries, pt. 2, 1839, Foraminifères, p. 132, pl. 2, figs. 1–3, 28.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 593, pl. 77, figs. 3–7.—FLINT, Rep. U. S. Nat. Mus., 1897 (1899), p. 321, pl. 69, fig. 2.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 5, pl. 2, figs. 7–9; pl. 9.

Description.—Test somewhat longer than broad, composed of two and one half to three coils arranged in a trochoid spire; chambers nine to twelve, inflated, somewhat appressed, globular, rapidly and regularly enlarging, four composing the last whorl; sutures deep; wall thick, reticulate; aperture large, semicircular, opening into the umbilicus in which the apertures of the preceding chambers may be visible.

Length of the figured specimen, 0.18 mm.; width, 0.15 mm.

Occurrence.—Exceedingly abundant in all three beds at the D. M. S. & B. Quarry. Rare in the Pliocene at Timms Point, San Pedro, California. Abundant in the Fernando and the Puente of the Los Angeles Basin.

The Lomita specimens which we have referred to this species are slightly broader in proportion to their length than d'Orbigny's model but they show the characteristic regularly enlarging, globular chambers which distinguish d'Orbigny's type.

The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

GLOBIGERINA CONCINNA Reuss

Plate 7, fig. 7

Globigerina concinna REUSS, Denksch. k. Ak. Wiss. Wien, vol. 1, 1850, p. 373, pl. 47, fig. 8.

Description.—Test subcircular in dorsal view, composed of ten to twelve inflated, moderately appressed, spherical chambers arranged in a low helicoid spire of about two and one half coils; chambers about four and one half in the last volution ventrally; sutures deep; wall reticulate; aperture a large circular opening into the umbilicus in which the aperture of the preceding chambers are also visible.

Length of the figured specimen, 0.20 mm.; width, 0.18 mm.

Occurrence.—Abundant in all three beds at the D. M. S. & B. Quarry. Rare in the Pliocene at Timms point, San Pedro, California. Rare in well samples from the Fernando of the Los Angeles Basin.

GLOBIGERINA CRASSAFORMIS, n. sp.

Plate 7, fig. 12

Pulvinulina crassa H. B. BRADY (not *Rotalina crassa* d'Orbigny), Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 694, pl. 103, figs. 11, 12.—FLINT, Rep. U. S. Nat. Mus., 1897 (1899), p. 329, pl. 74, fig. 2.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 58, pl. 27, fig. 1.

Description.—Test rotaliform, dorsal side flat, ventral side convexly rounded, umbilicate, periphery rounded, lobated; chambers few, usually about four in the last formed coil, inflated, rapidly increasing in size; sutures distinct, curved, deep, not limbate; wall granular or subspinose, very finely perforate; aperture an elongate opening extending from the umbilicus, where it is widest, almost to the peripheral margin and sometimes provided with a narrow lip.

Diameter of the type specimen, 0.40 mm.; height, 0.30 mm.

Holotype.—Columbia University Paleo. Coll. No. 19816, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in the middle bed at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material we have examined. Rare to common in well samples from the Saugus and rare in those from the Upper Pico of the Los Angeles Basin. Numerous authors have figured it from Recent material.

This species differs from *Rotalina crassa* d'Orbigny (Mem. Soc. Geol. France, vol. 4, 1840, p. 32, pl. 3, figs. 7, 8) from the Upper Cretaceous of France, by its more inflated chambers which are fewer to a coil; its deeper sutures; its more angled periphery and by the character of the aperture.

GLOBIGERINA CYCLOSTOMA, n. sp.

Plate 7, figs. 8, 9

Description.—Test subglobular, composed of about seven or eight rapidly and regularly enlarging, closely appressed chambers, three of which compose the final volution, the last chamber being somewhat flattened on top and composing slightly less than one-half of the test; wall coarsely reticulate, the angles between having spines or knobs which almost obscure the pores; sutures depressed, inconspicuous; aperture a circular opening at the center of the inner margin of the last chamber, with a slight lip and with several small rounded secondary apertures between the chambers at the top of the spire.

Length of the type specimen, 0.39 mm.; width, 0.35 mm.

Holotype.—Columbia University Paleo. Coll. No. 19818, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material examined. Present in a few well samples from the Saugus and the Upper and Lower Pico of the Los Angeles Basin.

This species differs from *G. rubra* d'Orbigny (in De la Sagra, Hist. Phys. Pol. Nat. Cuba, 1839, Foraminifères, p. 94, pl. 4, figs. 12–14), by its much more compact method of coiling, its less globular chambers, its more regularly formed trochoid coil and its small, circular aperture. Figure 9 shows a specimen from the middle bed in which the secondary apertures are obscure.

GLOBIGERINA (SPHAEROIDINELLA) DEHISCENS (Parker and Jones)

Plate 7, fig. 6

Sphaeroidina dehiscens PARKER and JONES, Phil. Trans., vol. 155, 1865, p. 369, pl. 19, fig. 5.
Sphaeroidinella dehiscens CUSHMAN, Contrib. Cushman Lab. Foram Res., vol. 3, pt. 1, 1927, p. 90, pl. 19, fig. 2*a*, *b*.

Description.—Test inflated, usually somewhat longer than broad, composed of a few chambers arranged in an irregular spiral in the early portion but with three chambers usually making up the entire visible portion of the test in the adult; the fully developed test marked by fissure-like sutures, the edges of which are slightly carinate, or sometimes becoming fimbrate and nearly closing the fissure; wall thick, in the young translucent, with large perforations, in the adult usually opaque with very large and conspicuous perforations, somewhat reticulate and rough; aperture an arched opening into the final chamber from the deep fissure near its base.

Length of the figured specimen, 0.65 mm.; width, 0.5 mm.

Occurrence.—A single specimen was found in the lower bed at the D. M. S. & B. Quarry. It is not present in the Timms Point Pliocene material. This, typically a recent species, has been recorded by many authors.

In spite of the coarse perforations and the rough and reticulate character of the adult test, all succeeding authors have followed Parker and Jones in failing to recognize that this species is a *Globigerina*. Since only one species has ever been found it is doubtful if Cushman's *Sphaeroidinella* is even a good subgenus.

GLOBIGERINA HELICINA d'Orbigny

Plate 7, fig. 10

Globigerina helicina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 277, No. 5.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 605, pl. 81, figs. 4, 5.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 12, pl. 3, figs. 1, 2.

Description.—Test oblong, composed of about ten chambers which are coiled in the early portion but which in the later are more or less irregularly added without regard to the early coil and are loosely appressed; sutures depressed; wall reticulate with coarse knobs or spines between the pores; apertures at the base of the irregularly added chambers with accessory openings between the other chambers.

Length of the figured specimen, 0.28 mm.; width, 0.18 mm.

Occurrence.—Very rare in all three beds at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material examined. Various authors have recorded it from the Recent oceans.

The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

GLOBIGERINA INFLATA d'Orbigny

Plate 8, fig. 1

Globigerina inflata D'ORBIGNY, in Barker, Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, 1839, Foraminifères, p. 134, pl. 2, figs. 7–9.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 601, pl. 79, figs. 8–10.—FLINT, Ann. Rep. U. S. Nat. Mus., 1897 (1899), pl. 69, fig. 3.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 8, pl. 4, figs. 4–8.

Description.—Test rotaloid in shape, dorsal surface nearly flat, ventral surface deep; periphery rounded, chambers closely appressed, four in the last whorl; wall reticulate but smoother than most other species of the genus; aperture a large crescentic opening extending from the umbilicus to the periphery, provided with a slight lip.

Diameter of the figured specimen, 0.20 mm.

Occurrence.—Fairly common in the upper and rare in the other two beds at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material examined. Rather rare in well samples from the Saugus and common in many of those from the Upper Pico of the Los Angeles Basin. This species has been described by many authors from the Recent oceans.

The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

GLOBIGERINA PACHYDERMA (Ehrenberg)

Plate 7, fig. 13

Aristerospira pachyderma EHRENBERG, Monatsberichte k. preuss. Ak. Wiss. Berlin, 1861, p. 303. *Globigerina pachyderma* H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 600, pl. 114, figs. 19, 20.

Description.—Test subglobular, coiled in a depressed spire, the last volution consisting of four chambers, the previous one indistinct; sutures scarcely depressed; wall thick, strongly reticulate, with the angles between the reticulations provided with spines or knobs; aperture a small, arched opening along the inner margin of the last formed chamber.

Length of the figured specimen, 0.35 mm.; width, 0.26 mm.

Occurrence.—Very abundant in all three beds at the D. M. S. & B. Quarry. Rare in the Pliocene at Timms Point, San Pedro, California. Abundant in well samples from the Saugus and the Upper Pico of the Los Angeles Basin. Recorded by various authors from Recent oceans.

The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

GLOBIGERINA QUADRILATERA, n. sp.

Plate 7, fig. 11

Description.—Test quadrate, consisting of about ten inflated chambers, four of which form the last whorl, regularly increasing in size up to the final segment which is typically smaller than the preceding, spire low; sutures deeply depressed; wall reticulate, with spines or knobs at the angles between the pores; aperture at the inner margin of the last chamber, opening into the umbilicus in which the apertures of the preceding chambers are often visible.

Length of the type specimen, 0.28 mm.; width, 0.26 mm.

Holotype.—Columbia University Paleo. Coll. No. 19824, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Common in all three beds at the D. M. S. & B. Quarry. Very rare in the Pliocene at Timms Point, San Pedro, California. Rare in well samples from the Saugus and the Upper Pico of the Los Angeles Basin and fairly common in those from the Lower Pico. Common in the Puente of the Basin.

This species is distinguished by its quadrate form and smaller last chamber. It differs from *G. diplostoma* Reuss (Denkschr. k. Ak. Wiss. Wien. Math.-Naturw. Cl., vol. 1, 1850, p. 373, pl. 47, figs. 9, 10, pl. 48, fig. 1) by its more closely appressed chambers and smaller last one.

GLOBIGERINA SUBCRETACEA Chapman

Plate 8, fig. 2

Globigerina subcretacea, CHAPMAN, Jour. Linn. Soc., Zoöl., vol. 28, 1902, p. 410, pl. 36, fig. 16.

Description.—Test subcircular in the dorsal view, composed of fourteen to fifteen loosely appressed chambers arranged in a low helicoid spire of about two to three volutions with six or seven chambers making up the last whorl; chambers gradually increasing in size; sutures depressed; wall reticulate; aperture a moderately large opening on the face of the last chamber and extending into the umbilicus in which the apertures of the preceding chambers are visible, provided with a slight lip.

Length of the figured specimen, 0.25 mm.; width, 0.23 mm.

Occurrence.—Abundant in all three beds at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material examined. Rare in well samples from the Saugus and the Upper Pico of the Los Angeles Basin. Chapman's type is Recent from the Funafuti Atoll.

Genus ORBULINA d'Orbigny, 1839

Genotype (monotypical) *O. universa* D'ORBIGNY, Hist. Phys. Pol. Nat. Cuba, Foraminifères, 1839, p. 3, pl. 1, fig. 1. (Recent, near Cuba.)—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 606.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 13; Bull. 104, pt. 5, 1924, p. 28.

Description.—Test spherical in the adult, completely embracing a globigerinoid nucleoconch in the microspheric form, which is missing in the megaspheric form and possibly at other times by resorption; walls typically thin, with fine, radiating spines which are missing in dead specimens; pores large, or large and small; aperture a single, simple, round opening, sometimes missing.

ORBULINA UNIVERSA d'Orbigny

Plate 8, fig. 3

Orbulina universa D'ORBIGNY, in De la Sagra, Hist. Phys. Pol. Nat. Cuba, 1839, Foraminifères, p. 3, pl. 1, fig. 1.

Description.—Test composed of a series of *Globigerina*-like chambers enclosed by a single, spherical chamber; wall reticulate with a pit at the bottom of each reticulation and with some of the perforations conspicuously large; the Lomita specimens lack the usual large circular aperture.

Diameter of the figured specimen, 0.37 mm.

Occurrence.—Very rare in all three beds in the D. M. S. & B. Quarry. Rare in the Pliocene at Timms Point, San Pedro, California. Rather rare in well samples from the Saugus, common in those from the Upper Pico and rare in those from the Lower Pico of the Los Angeles Basin. Many authors have figured this species from both fossil and Recent material.

The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

Family LAGENIDAE Reuss, 1861

Genus ASTACOLUS Montfort, 1808

Genoholotype *A. crepidulatus* MONTFORT, Conch. Syst., vol. 1, 1808, p. 262, text fig., renamed from *Nautilus crepidulus* Fichtel and Moll. Test. Micr., 1798, p. 107, pl. 19, figs. *g–i*. (Recent, coast near Leghorn, Italy.)

Periples MONTFORT, Conch. Syst., vol. 1, 1808, p. 270, Genre 68, text figs. copied from Soldani.
Crepidulina DE BLAINVILLE, Dict. Sci. Nat., vol. 32, 1824; vol. 12, Plates, pl. 19, fig. 8.
Cristellaria (part) of authors.

Description.—Test free, planispiral, involute in the early portion and evolute in the later portion, particularly the outer margin, with the chambers very oblique and reaching back, or nearly back, to the involute portion; surface smooth; periphery usually without carina; wall very finely perforate; aperture terminal, at the outer end of the last chamber, round, radiate. This genus differs from *Patrocles* in having only one whorl involute and the remainder evolute on the outside of the test and involute on the inside.

ASTACOLUS CALIFORNICUS, n. sp.

Plate 8, fig. 4

Cristellaria reniformis BAGG (not d'Orbigny), U. S. G. S. Bull. 513, 1912, p. 66, pl. 19, fig. 2.

Description.—Test much compressed, auriculate in outline, closely coiled in the early portion, later tending to become evolute, periphery provided with five keels on the initial and three prominent keels on the later portion of the test except for the apertural face; chambers about eight, all reaching to the umbonal region; sutures limbate and raised; wall smooth, very finely perforate; aperture small, round, not distinctly radiate, situated on the apertural face below the periphery.

Length of the type specimen, 0.5 mm.; width, 0.3 mm.

Holotype.—Columbia University Paleo. Coll. No. 19773, from the upper bed at the D. M. S. & B. Quarry.

Occurrence.—Bagg obtained a few specimens of this species from the Pliocene of Timms Point, San Pedro, California. We have found but one small specimen from the upper bed in the D. M. S. & B. Quarry.

ASTACOLUS PLANULATUS, n. sp.

Plate 8, fig. 5

Description.—Test elongate, flattened so that the two sides are parallel, early portion coiled, later becoming uncoiled but with the last chamber extending back to the early portion, periphery broadly rounded; chambers about eight; sutures curved, of clear shell material but not raised; wall smooth, very finely perforate; aperture a radiate opening on the outer peripheral margin of the last chamber.

Length of the type specimen, 0.55 mm.; width, 0.28 mm.

Holotype.—Columbia University Paleo. Coll. No. 19774, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—A single specimen was found in the middle bed at the D. M. S. & B. Quarry. It was not discovered in the Timms Point Pliocene material examined.

This form is characterized by its compressed elongate test, with nearly parallel sides and edges.

Genus FRONDICULARIA Defrance, 1824

Genotype (monotypical) *F. complanata* DEFRANCE, Dict. Sci. Nat., vol. 32, 1824, p. 178; vol. 12, Plates, pl. 14, fig. 4, called *Renulina complanata* and *Frondiculaire* in the text, and *Frondiculaire aplatie* on the plate. (Pliocene, near Siena, Italy.) *Frondicularia* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 256.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 518.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 81; Bull. 104, pt. 4, 1923, p. 139.

Description.—Test free, compressed; chambers arranged in a rectilinear series, numerous, narrow, closely appressed, shaped like an inverted V or equitant; wall hyaline, finely perforate, smooth or costate in various ways; aperture terminal, radiate or produced with a phialine lip with radial depressions.

FRONDICULARIA ADVENA Cushman

Plate 8, figs. 7, 8

Frondicularia inaequalis H. B. BRADY (not Costa), Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 521, pl. 66, figs. 8–12.—FLINT, Rep. U. S. Nat. Mus., 1897 (1899), p. 313, pl. 59, fig. 2.
Frondicularia advena CUSHMAN, U. S. Nat. Mus. Bull. 104, pt. 4, p. 141, pl. 20, figs. 1, 2.

Description.—Test compressed, subelliptical in side view, initial end usually narrow, bluntly pointed with a subspherical proloculum followed by early chambers which may or may not show traces of coiling, succeeded by the typical V-shaped frondicularian chambers; periphery usually with a slight, thin keel in the adult portion; sutures limbate, slightly depressed; wall smooth, translucent, thin; aperture a circular opening in the center of the periphery of the last formed chamber.

Length of the larger, imperfect, figured specimen, 1.8 mm.; width, 0.8 mm.

Occurrence.—Rare in the upper bed at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material examined. Not uncommon in well samples from the Upper Pico and rare in those from the Lower Pico and common in those from the Puente of the Los Angeles Basin. Cushman's type is from the Atlantic ocean.

In the Los Angeles Basin this species attains its greatest development in some of the Puente shales, where specimens greater than 6 mm. in length have been found. The Lomita as well as most of the Pliocene well specimens are broken.

Genus HEMICRISTELLARIA Stache, 1864

Genotype (first species, here designated) *H. procera* STACHE, *Novara*-Exped., Geol., vol. 1, pt. 2, 1864, p. 222, pl. 23, fig. 1. (Middle Tertiary, Auckland.)

Cristellaria (part) of Authors.

Description.—Test free, elongate, planispiral, early portion coiled in one whorl or less, later portion evolute, elliptical in section and angled or carinate on both edges; chambers numerous, closely appressed, somewhat oblique; wall hyaline, very finely perforate, smooth or knobbed or ribbed, especially on the early portion of the test; aperture near the outer periphery, produced, round, radiate. This genus differs from *Astacolus* in the less oblique chambers in the adult stage; from *Vaginulina* in the larger coiled portion.

HEMICRISTELLARIA GRANDIS, n. sp.

Plate 8, fig. 6

Description.—Test elongate, the adult portion slightly compressed, oval in section, edge slightly lobulate, early portion coiled in a planispiral whorl which is provided with a narrow carina which disappears on the evolute portion; chambers gradually increasing in length, about nine in the coiled portion and nine or ten in the evolute portion in the adult; sutures curved, limbate, raised in the coiled portion, slightly depressed in the adult; wall smooth, very finely perforate; aperture terminal, large, round, radiate.

Length of the type specimen, 6 mm.

Holotype.—Columbia University Paleo. Coll. No. 18931, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—A single individual was found in the lower bed at the D. M. S. & B. Quarry.

Genus VAGINULINA d'Orbigny, 1826

Genotype (designated by Cushman, 1913) *Nautilus legumen* LINNÉ, Syst. Nat. ed. 10, 1758, p. 711, named from Plancus, de Conch., 1739, p. 8, pl. 1, fig. 7. (Recent, Adriatic, at Rimini.)—D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 257.—BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 529.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 80; Bull. 104, pt. 4, 1923, p. 132.

Description.—Test free, elongate, flattened, curved, especially at the beginning, but not making one complete coil; edges angled, frequently carinate on one edge; chambers numerous, unilinear, closely appressed; sutures conspicuously oblique; wall hyaline, finely perforate, cross-ribbed or longitudinally striate or smooth; aperture marginal, round, radiate; apical end of the test sometimes with one or several spines. This genus differs from *Marginulina* in being flattened, with angled or carinate edges; from *Hemicristellaria* in lacking the conspicuous *Patrocles* stage; from *Planularia* in the more slender or sword-shaped test.

VAGINULINA ROBUSTA, n. sp.

Plate 8, fig. 9

Description.—Test large, elliptical in cross-section, both edges angled but not keeled, early portion curved, later straight or undulating, the initial end provided with a small keel; chambers in the early portion coiled planispirally so as to make about one-half a volution, becoming wider, less curved, and slightly inflated toward the apertural end of the test; sutures of clear shell material, limbate, widest on the convex side of the test, even with the surface in the early portion and becoming slightly depressed in the later; wall smooth, very finely perforate; aperture large, round, coarsely radiate, situated on the convex side of back or the test.

Length of the imperfect type, 4.5 mm.; width, 1.5 mm.

Holotype.—Columbia University Paleo. Coll. No. 19871, from the upper bed at the D. M. S. & B. Quarry.

Occurrence.—Very rare in the upper bed. We have not discovered it in the Timms Point Pliocene material.

Genus DENTALINA d'Orbigny, 1826 (1840)

Genotype (first species illustrated, here designated) *Nodosaria* (*Dentalina*) *obliqua* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 254; Model N. 5 ("*Les Dentalines*" in text, "*Dentalina*" on label of Model). (Recent, Adriatic.) D'ORBIGNY, Mém. Soc. Géol. France, vol. 4, pt. 1, 1840, p. 12; Foram. Foss. Vienne, 1846, p. 41.—REUSS, Sitz. Ak. Wiss. Wien, Math.-Naturw. Cl., vol. 44, pt. 1, 1861, p. 366.

Nodosaria (part) of authors.

Description.—Test free, elongate, curved, round in cross section, not carinate; chambers numerous, usually inflated fairly closely appressed vertically, uniserial,

gradually enlarging; sutures oblique, more so in the early stages; wall hyaline, finely perforate, smooth or costate; aperture terminal, round, radiate, submarginal on the side where the sutures go farthest upward, generally on the concave side of the test. The test is usually bent over backward as compared with *Marginulina*. This genus differs from *Nodosaria* in the oblique sutures, and not in the bent condition of the test, as is frequently stated.

DENTALINA BAGGI, n. sp.

Plate 8, figs. 14, 15

Nodosaria pauperata BAGG (not d'Orbigny) U. S. G. S. Bull. 513, 1912, p. 57, pl. 16, figs. 2 *a–f*.

Description.—Test elongate, slightly curved, circular in cross section, the initial chamber round, somewhat larger than those immediately succeeding; chambers inflated, closely appressed, somewhat irregularly increasing in size; sutures depressed, limbate, slightly curved; wall smooth, very finely perforate; aperture terminal, produced, round, radiate, situated near the concave side of the test.

Length of the broken type specimen, 4.0 mm.; diameter, 0.6 mm.

Holotype.—Columbia University Paleo. Coll. No. 19803, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Imperfect specimens of this species are common in all three beds at the D. M. S. & B. Quarry and perfect specimens in the Timms Point Pliocene.

This species differs from *D. pauperata* d'Orbigny (Foram. Foss. Vienne, 1846, p. 46, pl. 1, figs. 57, 58) by its larger, non-spinous, initial chamber, its less rapidly and irregularly enlarging chambers, and by its less produced aperture. It commonly attains great size. Bagg found specimens at Timms Point measuring more than 7 mm., and specimens 6 mm. in length are common. Most of the Lomita specimens are imperfect.

DENTALINA DECEPTA (Bagg)

Plate 8, figs. 12, 13

Nodosaria decepta BAGG, U. S. G. S. Bull. 513, 1912, p. 55, pl. 16, fig. 1.
Nodosaria seminuda BAGG (not Reuss), *ibid.*, p. 59, pl. 16, fig. 3.

Description.—Test large, curved, more so in the early part, the initial end with a short spine, the lower third typically ornamented with about eight or ten low costae which ascend obliquely or spirally and gradually fade out; chambers closely appressed in the first third of the test with slightly curved, scarcely depressed sutures, in the later portion becoming increasingly inflated toward the apertural end with slightly curved, depressed, limbate sutures; wall thick, smooth, matt in surface specimens, very finely perforate; aperture large, round, coarsely radiate, situated near the concave side of the test.

Length of the figured specimens, 6.00 mm.

Occurrence.—Rare in the middle bed at the D. M. S. & B. Quarry and in the Pliocene at Timms Point, San Pedro, California.

Bagg's figure does not show the costae which he mentions in his description.

His figured specimens of *D. seminuda* (not Reuss) seem to be identical in every way with *D. decepta* (Bagg). Some specimens which are otherwise identical lack the costae.

Genus OOLINA d'Orbigny, 1839

Genotype (most typical species, here designated) *O. laevigata* D'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, p. 19, pl. 5, fig. 3. (Recent, off west coast of South America.)

Cenchridium EHRENBERG, Bericht. k. preuss. Ak. Wiss. Berlin, 1845, p. 357.
Entosolenia WILLIAMSON, Ann. Mag. Nat. Hist., ser. 2, vol. 1, 1848, p. 5; Rec. Foram. Great Britain, 1858, p. 8.
Ovolina TERQUEM, Six. Mém. Foram. Lias, 1866, p. 473.
Lagenulina TERQUEM, Essai Anim. plage Dunkerque, 1876, p. 67.

Description.—Test free, monothalmous, ovate, round in cross section; wall hyaline, very finely perforate, smooth, costate or otherwise ornamented, without or with apical spine; aperture entosolenian, round, simple, sometimes with radiating grooves or ridges around the external part of the aperture. Length, up to 0.5 mm.

OOLINA LAEVIGATA d'Orbigny

Plate 8, fig. 10

Oolina laevigata D'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, 1839, p. 19, pl. 5, fig. 3.

Description.—Test pyriform, round in cross-section, anterior portion with a prolongation more transparent than the body of the test and terminated by a round, radiate aperture; wall very finely perforate.

Length of the figured specimen, 0.50 mm.; diameter, 0.35 mm.

Occurrence.—Rare in the lower bed at the D. M. S. & B. Quarry. Very rare in the Pliocene of Timms Point, San Pedro, California.

This species may be readily distinguished by its pyriform shape and its radiate aperture, a character of rare occurrence in the genus. In this respect it bears a strong resemblance to the protoconch of several of the Nodosariinae

Genus ROBULUS Montfort, 1808

Genoholotype *R. cultratus* MONTFORT, Conch. Syst., vol. 1, 1808, p. 215, text figs. (Pliocene, near Coroncina, Italy.)

Robulina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 287, genotype, here designated, *Robulus cultratus* Montfort.—REUSS, Sitz. k. Ak. Wiss. Wien, Math.-Naturw. Cl., vol. 44, pt. 1, 1861, p. 369.
Cristellaria (part) of authors.

Description.—Test free, nautiloid, lenticular, thick or thin, carinate or keeled; chambers numerous, embracing to umbilicus usually; wall hyaline, very finely perforate, smooth or ornamented; aperture a triangular or elongate slit just below the outer point of the last chamber, in the plane of coiling, radiate on the outside; last septum frequently concave. This genus differs from *Patrocles* in the elongate aperture.

ROBULUS CUSHMANI, n. sp.

Plate 8, fig. 11

Description.—Test large, close coiled, thick, typically provided with a large central umbo of clear shell material; peripheral margin terminated by a prominent, sharp, limbate keel; chambers about eight or nine in the last formed whorl; sutures broad, limbate, somewhat curved, meeting the umbo tangentially, typically raised in the early portion of the coil and tending to be depressed in the later; aperture large, radiate with an elongate slit on the apertural face; radiations of the previous apertures visible on the preceding chambers.

Length of the type specimen, 2.5 mm.; thickness, 1.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19848, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rather common in all three beds at the D. M. S. & B. Quarry. Very rare in the Pliocene of Timms Point, San Pedro, California. A few specimens have been found in well samples from the Saugus and the Upper Pico. Rare in well samples from the Lower Pico and the Puente of the Los Angeles Basin.

It is probable that *Cristellaria rotulata* (Lamarck), of Cushman (Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 108, pl. 28, figs. 1, 2, not pl. 22, fig. 2) and doubtless many other specimens included by various authors under the name *Cristellaria rotulata* (Lamarck) should be referred to this species and genus although few authors mention the characteristic robuline aperture. *Lenticulites rotulata* Lamarck which most authors refer to as *Cristellaria rotulata* (Lamarck) (Ann. du Mus., vol. 5, No. 3, 1804, p. 188; Tab. encyl. et méthod., Pl. CCCCLXVI, fig. 5), appears from the original figure to be a species of nummulite. However, as no aperture is shown, its genus cannot be definitely determined from Lamarck's undescribed figure.

Genus CARININA, n. gen.

Genoholotype *Pulvinulina repanda* var. *menardii*, subvar. *pauperata* PARKER and JONES, Phil. Trans., vol. 155, 1865, p. 395, pl. 16, figs. 50, 51. (Recent, North Atlantic.)

Pellatispira CUSHMAN (not Boussac), Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 93, pl. 20, fig. 3.

Description.—Test free or attached to plants, planispiral, biconvex or plano-convex, depressed, consisting of one or two whorls of inflated chambers which are loosely appressed, visible on both sides of the test, and surrounded on the periphery by a very wide flange or carina; wall very finely perforate, smooth; aperture a small, distorted opening at the outer side of the septal face near the periphery of the test.

CARININA CARINATA, n. sp.

Plate 9, fig. 3

Description.—Test attached to plants in life, plano-convex, provided with a very broad, thin flange with a rounded keel; chambers arranged in two whorls, globular, scarcely touching, separated by deep sutures, those in the last whorl pro-

vided with a slight tubercle of clear shell material; wall hyaline; aperture a small slit where the flange on the last chamber joins the flange of the previous whorl.

Diameter of the type specimen, 0.80 mm.

Holotype.—Columbia University Paleo. Coll. No. 19786, from the lower bed in the D. M. S. & B. Quarry.

Occurrence.—Very rare in the lower bed in the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene Material which we have examined.

This species is characterized by the thin broad plate upon only one side of which the chambers are arranged.

Genus FISSURINA Reuss, 1850

Genotype (monotypical) *F. laevigata* REUSS, Denkschr. k. Ak. Wiss. Wien, Math.-Naturw. Cl., vol. 1, 1850, p. 366, pl. 46, fig. 1. (Middle Miocene, Austria.)—REUSS, Sitz. k. Ak. Wiss. Wien, Math.-Naturw. Cl., vol. 46, pt. 1, for 1862, 1863, p. 338, pl. 6, fig. 84.—SEGUENZA, Foram. Monotal. Miocen. Messina, 1862, p. 53.

Hyaleina COSTA, Atti Accad. Pontaniana, vol. 7, fasc. 1, pt. 2, 1853 (1856), pl. 18, figs. 22–25.
Lagena (part) of authors.

Description.—Test free, monothalmous, oval in longitudinal section, mostly elliptical in cross-section, with or without peripheral keel; wall hyaline, very finely perforate, usually smooth; aperture entosolenian, the external orifice elongate parallel to the greater diameter of the test, somewhat produced but neither phialine nor radiate. Length, 0.2 to 1.5 mm.

FISSURINA OBSCUROCOSTATA, n. sp.

Plate 9, fig. 1

Description.—Test ovate in side view, broadly elliptical in apertural view, provided with a narrow, rounded keel; wall ornamented with twelve rounded costae extending from the base two-thirds of the way toward the aperture; wall very finely perforate; aperture an elliptical opening extending into an entosolenian tube.

Length of the type specimen, 0.23 mm.; width, 0.21 mm.

Holotype.—Columbia University Paleo. Coll. No. 19808, from the middle bed at the D. M. S. &. B. Quarry.

Occurrence.—A single specimen was discovered in the middle bed at the D. M. S. & B. Quarry. A few specimens have been found in well samples from the Saugus of the Los Angeles Basin.

This species is distinguished by its obscure costae.

FISSURINA ROMETTENSIS Seguenza

Plate 9, fig. 2

Fissurina romettensis SEGUENZA, Foram. Monotal. Miocen. Messina, 1862, p. 70, pl. 2, figs. 42, 43.

Description.—Test circular in side view, elliptical in apertural view, provided with a thin, broad, peripheral carina of clear shell material, about 0.01 mm. in width, extending completely around the test and bounding the neck; wall smooth, very finely perforate; aperture a small rounded opening at the bottom of an elongate slit.

Diameter of the figured specimen, 0.38 mm.

Occurrence.—Single specimens of this species were found in the middle bed at the D. M. S. & B. Quarry and in the Pliocene, at Timms Point, San Pedro, California. A few specimens have been found in well samples from the Saugus and one in a sample from the Upper Pico, of the Los Angeles Basin. Seguenza's type came from the Miocene of Messina.

The thin broad carina surrounding the test serves to distinguish this species. The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

Genus POLYMORPHINA d'Orbigny, 1826

Genotype (first species illustrated, here designated) *P. burdigalensis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 265, Model No. 29. (Miocene, near Bordeaux.)—D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 231.—H. B. BRADY, PARKER and JONES, Trans. Linn. Soc. London, vol. 27, 1870, p. 197.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 557.—CHAPMAN, Foraminifera, 1902, p. 199.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 83; Bull. 104, pt. 4, 1923, p. 145.

Misilus MONTFORT, Conch. Syst., vol. 1, 1808, p. 294, Genre 74. Not definitely recognizable.
Cantharus MONTFORT, *ibid.*, p. 298, Genre 75. Not definitely recognizable.
Arethusa MONTFORT, *ibid.*, p. 302, Genre 76. Not definitely recognizable.
Raphanulina ZBORZEWSKI, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. 3, 1834, p. 311, pl. 28, fig. 1 *a*. (Fistulose form.)
Apiopterina ZBORZEWSKI, *ibid.*, p. 311, pl. 28, fig. 2 *b*.
Aulostomella ALTH, Haidigner's Nat. Abh., vol. 3, pt. 2, 1850, p. 264. (A fistulose form.)
Rostrolina SCHLICHT, Foram. Septar. Pietzpuhl, 1870, pls. 25, 26.

Description.—Test free, rarely attached, elongate, compressed or rounded in cross-section; chambers numerous, arranged biserially or triserially, in a high spire; wall calcareous, finely perforate, smooth, costate or spinose; aperture terminal, radiate, sometimes with internal tube, rarely fistulose. Length, 0.5 to 3 mm. or more.

Subgenus POLYMORPHINA sensu stricto

Description.—Test free, elongate, compressed; chambers numerous, arranged biserially, with a tendency to twist, shown by the chambers reaching down farther toward the apex on one edge of the test and on the opposite edge on the other side of the test; wall finely perforate, usually smooth, sometimes striate or spinose; aperture terminal, radiate, rarely fistulose, sometimes entosolenian.

POLYMORPHINA BISERIALIS, n. sp.

Plate 9, fig. 4

Polymorphina complanata BAGG (not d'Orbigny), U. S. G. S. Bull. 513, 1912, p. 69, pl. 20, figs. 13, 14.

Description.—Test elongate compressed with nearly parallel edges which are angled in edge view, widest near the apertural end, composed of six or seven pairs of rhomboidal chambers arranged in two nearly equal series; sutures narrow, limbate, scarcely depressed; wall smooth, very finely perforate; aperture large,

coarsely radiate, slightly produced, at the end of a ring of clear shell material which is visible on each preceding chamber, and further provided with an entosolenian tube or siphon which extends the full length of the test.

Length of the type specimen, 2.7 mm.; width, 0.8 mm.

Holotype.—Columbia University Paleo. Coll. No. 19837, from the upper bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Bagg discovered six specimens of this species in the Pleistocene at Santa Barbara. It is rare in the material which we have collected from the Pliocene of Timms Point, San Pedro, California.

This species resembles *P. complanata* d'Orbigny (Foram. Foss. Vienne, 1846, p. 234, pl. 13, figs. 25–30) in no respect other than the compressed character of its test. It is readily distinguished by its long compressed test with nearly parallel edges, and particularly by the character of the aperture with its long internal siphon. Our Lomita specimens, which are megaspheric forms, have a large, round proloculum.

POLYMORPHINA DOANEI, n. sp.

Plate 9, fig. 8

Bulimina contraria BAGG (not Reuss), U. S. G. S. Bull. 513, 1912, p. 37, pl. 9, fig. 2.
Polymorphina nodosaria BAGG (part, not Reuss), *ibid.*, p. 71, pl. 21, figs. 2, 3 (not fig. 1).

Description.—Test subfusiform, nearly round in end view, consisting, in the adult, of about two coils of seven to nine inflated chambers, arranged three to a volution in the early part, the last two much larger than the previous ones; sutures distinct, depressed; wall smooth, very finely perforate; aperture round, radiate, produced.

Length of the type specimen, 1.5 mm.; diameter, 0.7 mm.

Holotype.—Columbia University Paleo. Coll. No. 19839, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three of the beds at the D. M. S. & B. Quarry. Rare in the Pliocene of Timms Point, San Pedro, California.

Bagg has figured a submature specimen as *Bulimina contraria* Reuss, a form to which it bears no resemblance. It differs from *P. nodosaria* Reuss in lacking the uniserial arrangement of the chambers.

This species has been named for Mr. George H. Doane.

POLYMORPHINA ELONGATA, n. sp.

Plate 9, fig. 7

Polymorphina compressa BAGG (part, not d'Orbigny), U. S. G. S. Bull. 513, 1912, p. 69, pl. 20, figs. 19–21 (not figs. 7–9, nor. pl. 21, figs. 9–11).

Description.—Test elongate, flattened in side view with broadly rounded edges and obtusely rounded apical end; chambers closely appressed, arranged in two unequal, biserial series; sutures limbate, nearly flush with the surface; wall smooth, very finely perforate; aperture large, rounded, coarsely radiate, situated at the end

of a projection of clear shell material which is distinctly visible on each preceding chamber, and further provided with an entosolenian tube or siphon which connects the preceding apertures.

Length of the type specimen, 2.6 mm.; width, 0.9 mm.

Holotype.—Columbia University Paleo. Coll. No. 19840, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Common in the Pliocene of Timms Point, San Pedro, California. Bagg records this species as rare in the Pleistocene at Santa Barbara, California.

This species is distinguished from *P. biseralis*, n. sp. by its fewer and longer chambers which are arranged in two unequal, biserial series.

POLYMORPHINA FRONDICULARIFORMIS, n. sp.

Plate 9, fig. 6

Frondicularia inaequalis BAGG (not Costa), U. S. G. S. Bull. 513, 1912, p. 60, pl. 18, figs. 1, 2.

Description.—Test elongate, lanceolate, compressed, the initial end with a sharp spine; chambers numerous, narrow and long, biserially arranged so that when viewed from either side the left-hand series composes over half of the test; sutures of clear shell material, slightly if at all depressed; wall smooth, very finely perforate; aperture produced, round, radiate.

Length of type specimen, 2 mm.; breadth, 0.8 mm.; thickness, 0.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19872, from the upper Pliocene of Timms Point, San Pedro, California.

Occurrence.—Common in the Pliocene of Timms Point, San Pedro, California, very rare in the lower bed at the D. M. S. & B. Quarry.

This *Polymorphina* is characterized by its frondicularian-shaped test, which has caused it to be confused with *Frondicularia*. It is, however, clearly biserial and not uniserial.

POLYMORPHINA TORTA, n. sp.

Plate 9, fig. 5

Description.—Test elongate elliptical, compressed and twisted through 180°, the initial end with a blunt spine; chambers numerous, narrow and long, biserially arranged, so that when viewed from either side the left-hand series composes over half the test; sutures slightly depressed; wall smooth, finely perforate; aperture produced, round, radiate.

Length of type specimen, 1.7 mm.; width, 0.5 mm.

Holotype.—Columbia University Paleo. Coll. No. 19845, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—This species is fairly common in the lower bed and rare in the upper bed at the D. M. S. & B. Quarry. It is very rare in the Pliocene of Timms Point, San Pedro, California.

This species was obviously derived from *P. frondiculariformis* by twisting of the test. That it is specifically distinct from *P. frondiculariformis* is also shown by the greater number of specimens in the Pleistocene, whereas the ancestral form which is not twisted is more common in the Pliocene.

POLYMORPHINA OBSCURICOSTATA, n. sp.

Plate 9, fig. 12

Description.—Test flattened, irregularly oval in side view, consisting of about four flattened chambers biserially arranged; surface ornamented with about six low, obscure costae to a side extending from the rounded apical end about two-thirds of the way to the aperture, very finely perforate; aperture small, slightly produced, round, radiate.

Length of the type specimen, 0.22 mm.; width, 0.13 mm.; thickness, 0.05 mm.

Holotype.—Columbia University Paleo. Coll. No. 19843, from the middle bed in the D. M. S. & B. Quarry.

Occurrence.—A single specimen was found in the middle bed at the D. M. S. & B. Quarry. It was not present in the Timms Point Pliocene material examined.

This species is characterized by its low obscure costae and fairly small, flattened test.

POLYMORPHINA SUBELLIPTICA, n. sp.

Plate 9, fig. 11

Description.—Test subelliptical in side view, slightly compressed, apical end broadly rounded; chambers few, elongate, closely appressed; early ones arranged three in a coil, later two; sutures shallow, limbate; wall smooth, very finely perforate; aperture only slightly produced, with a broad collar of clear shell material which is visible on the previous chambers.

Length of the type specimen, 1.4 mm.; diameter, 0.6 mm.

Holotype.—Columbia University Paleo. Coll. No. 19844, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Very rare in the middle bed at the D. M. S. & B. Quarry. It was not present in the Timms Point Pliocene material which we have examined.

This species may be distinguished from *P. elongata* by its shorter and more oblique chambers and its more smoothly formed test.

Subgenus GUTTULINA d'Orbigny, 1826

Genotype (most common species, here designated) *Polymorphina* (*Guttulina*) *communis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 266; Model No. 62. (Pliocene, Castel-Arquato, Italy.) —PARKER, JONES and BRADY, Ann. Mag. Nat. Hist., ser. 3, vol. 16, 1865, p. 29, pl. 2, fig. 50.
Guttulina D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 222.
Polymorphina (part) of authors.

Description.—Test free, bulbous, consisting of inflated chambers with correspondingly depressed sutures, which are arranged in a spire with about three chambers to a whorl; aperture produced, terminal, round, radiate, rarely fistulose.

POLYMORPHINA (GUTTULINA) AUSTRIACA d'Orbigny

Plate 9, fig. 9

Guttulina austriaca D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 223, pl. 12, figs. 23–25.
Polymorphina problema BAGG (part, not d'Orbigny), U. S. G. S. Bull. 513, 1912, p. 73, pl. 20, figs. 1–3 (not figs. 4–6).

Description.—Test short fusiform, broadest about the middle, apical end broadly rounded, subtriangular in end view; about four or five, elongate, triserially arranged, inflated chambers; sutures slightly depressed, not limbate; wall smooth, very finely perforate; aperture produced, round, radiate.

Length of the figured specimen, 0.23 mm.; width, 0.14 mm.

Occurrence.—Rare in all three of the beds at the D. M. S. & B. Quarry. Very rare in the Pliocene of Timms Point, San Pedro, California.

The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

POLYMORPHINA (GUTTULINA) COSTATULA, n. sp.

Plate 9, fig. 10

Description.—Test short, fusiform, subtriangular in cross-section, apical end bluntly pointed, composed of about five elongate, inflated, triserially arranged chambers; sutures slightly depressed, not limbate; wall ornamented with about twelve to fifteen low, rounded costae, some of which are continuous from one chamber to the next, very finely perforate; aperture small, produced, round, radiate.

Length of the type specimen, 0.58 mm.

Holotype.—Columbia University Paleo. Coll. No. 19838, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in the lower bed at the D. M. S. & B. Quarry.

This species differs from *P. regina* Brady, Parker and Jones (Trans. Linn. Soc. London, vol. 27, 1870, p. 241, pl. 41, fig. 32) by its more elongate, triangular test and its more produced aperture. It is identical with our *P. austriaca* except for the presence of the costae.

Family ROTALIIDAE Reuss, 1861

Genus GLOBOROTALIA Cushman, 1927

Genoholotype *Pulvinulina menardii* var. *tumida* H. B. BRADY, Geol. Mag., Dec. 2, vol. 4, 1877, p. 294. (Pliocene, New Mecklenburg, Bismarck Archipelago.)

Pulvinulina tumida SCHUBERT, Abh. geol. Reichs., vol. 20, pt. 4, 1911, p. 111, pl. 1, fig. 1 *T*; pl. 5, figs. 1 *T*, 4 *P*. (Topotypes.)—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 692, pl. 103, figs. 4–6.
Globorotalia CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 91.

Description.—Test free, rotaloid, all chambers visible on the dorsal side, only those of the last whorl visible on the ventral side, unequally biconvex, umbilicate but not umbonate on the ventral side, generally more convex dorsally; peripheral margin angled or carinate; chambers numerous, closely appressed, enlarging gradually or rapidly; walls very finely perforate, smooth or ornamented with

limbate sutures or tubercles; aperture a slit widest in or near the umbilicus and extending part way to the periphery, with or without valvular lip. Diameter, 0.3 to 2 mm.

This genus is distinguished from *Rotalia* by the open umbilicus, and the aperture which is in or near the umbilicus instead of being near the periphery; from *Rosalina* by the finer perforations; from *Lamarckina* by being free and with smaller umbilicus.

GLOBOROTALIA CAMPANULATA, n. sp.

Plate 9, fig. 14

Description.—Test trochoid or bell-shaped, composed of numerous whorls, dorsal side highly convex, ventral slightly concave or flat except for the last formed chamber which projects; periphera margin rounded and limbate; chambers numerous, about six in the last volution; sutures nearly straight and tangent to the periphery of the previous coil dorsally, depressed ventrally and slightly irregular; umbilicus depressed or sometimes provided with a rounded knob of clear shell material; wall finely perforate; aperture an elongate slit extending into the umbilicus.

Diameter of the type specimen, 0.23 mm.; thickness, 0.14 mm.

Holotype.—Columbia University Paleo. Coll. No. 19827, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Very rare in the Pliocene at Timms Point, San Pedro, California. It is very likely that this is the same form which Bagg identified as *Discorbina vilardeboana* (d'Orbigny) from the Pleistocene of Santa Barbara, California (U. S. G. S. Bull. 513, 1912, p. 82, pl. 28, figs. 9, *a–c*). As Bagg did not figure his specimens but reproduced those given in the *Challenger* Report, this cannot be definitely determined until some of the Santa Barbara material is examined.

This species is distinguished by its trochoid or bell-shaped chambers. It differs from *Rosalina vilardeboana* d'Orbigny (Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, 1839, p. 44, pl. 6, figs. 13–15), particularly by lacking the coarse perforations.

GLOBOROTALIA GRANDIS, n. sp.

Plate 9, fig. 15

Pulvinulina punctulata JONES, Palaeo. Soc. Mono., pt. 4, 1897, p. 319, pl. 2, figs. 22–24.—BAGG, U. S. G. S. Bull. 513, 1912, p. 86, pl. 25, figs. 6–9.

Pulvinulina repanda BAGG, U. S. G. S. Bull. 513, 1912, p. 87, pl. 24, figs. 5–8.

Description.—Test unequally biconvex, ventral side the larger and umbilicate, the periphery somewhat lobulate and provided with a blunt keel; chambers about six or seven in the last whorl; sutures on the dorsal side curved and limbate, on the ventral side slightly curved, radial and depressed; wall thick, finely perforate, the dorsal surface pitted or smooth; aperture an elongate opening extending from near the periphery into the umbilicus; the ventral surface is partly absorbed or corroded in some specimens, particularly near the umbilicus. Diameter, up to 2 mm. or more.

Diameter of type specimen, 1.5 mm.; thickness, 0.36 mm.

Holotype.—Columbia University Paleo. Coll. No. 19828, from the middle bed at the D. M. S. & B. Quarry.

Very rare in all three beds at the D. M. S. & B. Quarry. Fairly common in the Pliocene at Timms Point, San Pedro, California, and in well samples from an equivalent horizon in the Saugus of the Los Angeles Basin. The Quarry specimens are considerably calcified and more poorly preserved than the Timms Point or well specimens.

GLOBOROTALIA MCCOLLOMI, n. sp.

Plate 9, fig. 13

Description.—Test unequally biconvex, ventral side more so, ovate in side view, periphery provided with a broad, rounded, limbate keel, slightly lobulate; chambers five or six in the last whorl; sutures on the ventral side slightly depressed, slightly curved and radial, on dorsal side nearly straight and tangent to the periphery of the previous coil; wall thickened and pitted on the dorsal side, very finely perforate; aperture an elongate opening which extends nearly or quite to the umbilicus; the umbilicus may be open or in older specimens nearly filled with clear shell material, is usually large, and serrate in some specimens; the ventral surface is partly absorbed or corroded in the largest specimens, particularly around the umbilicus. Diameter, up to 2 mm.

Diameter of the type specimen, 0.6 mm.; thickness, 0.36 mm.

Holotype.—Columbia University Paleo. Coll. No. 19829, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Very rare in the Pliocene at Timms Point, San Pedro, California, and in well samples from an equivalent horizon in the Saugus of the Los Angeles Basin.

This species is named for Mr. C. R. McCollom, well-known geologist of California.

Genus ROTALIA Lamarck, 1804

Genotype (first species, here designated) *R.* (*Rotalites*) *trochidiformis* LAMARCK, Ann. Mus., vol. 5, 1804, p. 184; vol. 8, 1806, pl. 62, fig. 8. (Middle Eocene, Grignon, France.) The type species cannot be *Nautilus beccarii* Linné, as stated by Cushman, 1915, since Lamarck did not include that species in his original list.

Rotalites LAMARCK, *ibid.*, used for fossil species of *Rotalia*.
Rotalina D'ORBIGNY, Hist. Phys. Nat. Cuba, 1839, Foraminifères, p. 75.
Trochulina D'ORBIGNY, subgenus of *Rotalia*, Ann. Sci. Nat., vol. 7, 1826, p. 274; Model No. 73.
Rotalia BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 702.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 66.

Description.—Test free, trochoid or biconvex, spiral, all the whorls visible on the dorsal side, only the last whorl visible on the ventral side (rotaloid); ventral side with umbo or small umbilicus; chambers numerous, closely appressed, enlarging gradually; wall very finely perforate; aperture a slit at the base of the last chamber near the periphery, or an arched slit midway between umbo and periphery; test frequently covered with an exogenous deposit, or ornamented with

tubercles, limbate sutures, bosses or costae. The larger species have double septa and interseptal canals. Diameter, 0.5 to 1.5 mm.

The typical form of *Rotalia* is a trochoid spire with a flat base and the aperture near the periphery. One subgenus, *Streblus*, can be recognized.

ROTALIA SUBTENERA, n. sp.

Plate 10, fig. 4

Description.—Test biconvex, dorsal side nearly flat, ventral side deep, periphery angled but not carinate, very slightly lobulated, ventral side with slight umbilicus, chambers about eight in the last formed coil; sutures on the dorsal side straight, not radial (i.e., not directed exactly toward the center of the test), very slightly limbate, and on the ventral side straight, radial and slightly depressed; wall smooth, very finely perforate; aperture a curved slit at the middle of the base of the last chamber and provided with a slight lip.

Diameter of the type specimen, 0.35 mm.; thickness, 0.18 mm.

Holotype.—Columbia University Paleo. Coll. No. 19852, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in the middle and the upper bed at the D. M. S. & B. Quarry. Not present in the Timms Point material which we have. Abundant in some well samples from the Saugus of the Los Angeles Basin. Very rare in the Upper and Lower Pico well samples.

This species may be distinguished from *R. tenera* (H. B. Brady) (Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 665, pl. 95, figs. 11 *a–c*) by its greater number of chambers, more nearly plano-convex test, lower central umbo, less lobated outline, and the lack of a keel.

Genus EPISTOMINA Terquem, 1883

Genotype (here designated) *E. regularis* Terquem, Cinquième Mém. Foram. Oolithique, 1883, p. 379, pl. 44, figs. 1–3. (Lower Jurassic, Fontoy, France.)

Epistomina Terquem, Bull. Soc. Géol. France, ser. 3, vol. 11, 1883, p. 37, pl. 3, no species named.

Description.—Test free, rotaloid, unequally biconvex, carinate, dorsal side usually the larger, spire visible only on the dorsal side, sometimes umbilicate on the ventral side; chambers numerous and closely appressed; walls calcareous, finely porous; aperture on the base of the last septal face, round or slit-like, with or without peristome, situated near the outside, on the middle or near the inner suture; diameter up to 1 mm. This genus differs from *Rotalia* in possessing a secondary aperture, and in the less regularity of form and ornamentation.

EPISTOMINA BRADYI, n. sp.

Plate 10, fig. 1

Pulvinulina partschiana H. B. Brady (not d'Orbigny), Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 699, pl. 105, fig. 3.

Description.—Test unequally biconvex, ventral side more so, periphery subacute, provided with a slightly rounded limbate keel; chambers about nine or ten in the last formed coil; sutures curved, limbate, flush with the surface dorsally, in

the adult slightly depressed ventrally, slightly raised in young specimens, the ends uniting to form an umbonate mass of clear shell material in the umbilical region; wall smooth, hyaline to opaque, without variegated markings, very finely perforate; aperture an elongate slit on the ventral side at the base of the last septal face, starting midway between the central umbo and the periphery and extending almost to the peripheral keel and provided with a slight lip; each chamber being further provided with a secondary opening on the ventral side just below and parallel to the keel, which in previous chambers is still visible though filled with clear shell material.

Diameter of the type specimen, 0.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19806, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry and in the Timms Point Pliocene. Very rare in well samples from the Saugus and Upper Pico and abundant in those from the Lower Pico of the Los Angeles Basin. It is a good guide-fossil for the Lower Pico. Brady's specimens are Recent.

This species has been described by most authors as *E. partschiana* (d'Orbigny) (Foram. Foss. Vienne, 1846, p. 153, pl. 7, figs. 28–30, pl. 8, figs, 1–3.). A glance at d'Orbigny's figures will show that it differs from the latter species in the unequal convexity of the test and particularly by the absence of raised sutures and a raised umbo on the ventral side. Many of the well specimens are over 1.00 mm. in diameter but the larger specimens at Lomita are usually imperfect owing to the presence of the secondary aperture which makes the attachment of the final segment rather insecure.

EPISTOMINA FLINTI, n. sp.

Plate 9, fig. 16

Pulvinulina elegans H. B. BRADY (not D'ORBIGNY), Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 699, pl. 105, figs. 4–6.—FLINT, Rep. U. S. Nat. Mus., 1897 (1899), p. 331, pl. 75, fig. 1.

Description.—Test large, nearly equally biconvex, periphery bluntly rounded; chambers about nine or ten in the last whorl; sutures limbate, flush with the surface; walls thickened, beautifully marked by an irregular pattern of dots, lines, and irregular areas of clear shell material on a white opaque background, very finely perforate; aperture an elongate slit on the ventral side at the base of the last chamber midway between the periphery and the umbilical region, provided with a slight lip, each chamber being further provided with a secondary opening on the ventral side just below and parallel to the periphery, which in the previous chambers is still visible though filled with clear shell material.

Diameter of the type specimen, 2.3 mm.; thickness, 1.0 mm.

Holotype.—Columbia University Paleo. Coll. No. 19807, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in the lower bed at the D. M. S. & B. Quarry. Not present in the Timms Point Pliocene material examined. Flint's specimens are Recent.

Genus ROSALINA d'Orbigny, 1826

Genotype (first species, here designated) *R. globularis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 271, pl. 13, figs. 1–4; Model No. 69. (Recent, sea shore.)—Hist. Phys. Nat. Cuba, 1839, Foraminifères, p. 89; Foram. Foss. Vienne, 1846, p. 173.

Turbinolina D'ORBIGNY, Hist. Phys. Nat. Cuba, 1839, Foraminifères, p. 89.

Auriculina COSTA, Atti Accad. Pontaniana, vol. 7, pt. 2, 1856, p. 259. (Homonym of *Auriculina* Grateloup, 1838.)

Discorbina PARKER AND JONES, in Carpenter's Introd. Foram., 1862, p. 203.—PARKER, JONES AND BRADY, Ann. Mag. Nat. Hist., ser. 3, vol. 16, 1865, p. 25, "*Discorbina* . . . . the type being *D. Turbo*, D'Orb., sp."—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 640, p. 642. "*Discorbina turbo*, the type of the genus."

Discorbis (part) Cushman, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 10. (Not *Discorbis* and *Discorbites* Lamarck, 1804, which is an unrecognizable rotaloid.)

Description.—Test free or attached to organisms by the ventral side, rotaloid, dorsal side more convex and showing the spire, only the last whorl visible on the ventral side; chambers numerous, globular or closely appressed, enlarging rapidly, the last chamber frequently constituting a third or more of the ventral side; sutures depressed or limbate; wall generally smooth, hyaline, coarsely perforate, pores 0.007 to 0.015 mm. in diameter, averaging about 0.008 mm.; aperture at the base of the last chamber, slit-like, widest in or near the umbilicus and extending part way to the periphery, with or without valvular lip. Diameter, 0.25 to 1 mm. This genus differs from *Globorotalia* in being more coarsely perforate. It includes most species of *Discorbis* and *Discorbina* of authors.

ROSALINA HITCHCOCKAE, n. sp.

Plate 10, fig. 2

Description.—Test rotaliform, unequally biconvex, the ventral side much more so and deeply umbilicate, the peripheral margin bluntly rounded and keeled; chambers about eight in the last whorl, the last much larger; sutures curved, broadly limbate, raised on the dorsal side and depressed on the ventral; wall smooth, hyaline, conspicuously perforate; aperture a curved slit at the base of the last chamber, largest near the umbilicus.

Diameter of the type specimen, 0.8 mm.; thickness, 0.49 mm.

Holotype.—Columbia University Paleo. Coll. No. 19850, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in the lower bed at the D. M. S. & B. Quarry and in the Timms Point Pliocene.

This species is named for Miss Margaret Hitchcock, who discovered it.

ROSALINA ISABELLEANA d'Orbigny

Plate 10, fig. 3

Rosalina isabelleana D' ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, 1839, p. 43, pl. 6, figs. 10–12.

Description.—Test rotaliform, biconvex, the dorsal side slightly more so, peripheral margin somewhat lobulate and bluntly rounded, chambers about fifteen,

five making up the last whorl, the last composing one-third or more of the ventral side; sutures arched dorsally, depressed, slightly curved and radial ventrally; wall smooth, hyaline, coarsely perforate; aperture on the ventral side at the base of the last chamber with a slight lip.

Diameter of the figured specimen, 0.3 mm.

Occurrence.—A single specimen was found in the lower bed at the D. M. S. & B. Quarry.

Genus CIBICIDES Montfort, 1808

Genoholotype *C. refulgens* MONTFORT, Conch. Syst., vol. 1, 1808, p. 122, text fig. (Recent, Adriatic.)

Storilus MONTFORT, *ibid.*, p. 131, Genre 33.

Polyxenes MONTFORT, *ibid.*, p. 139, Genre 35. (?)

Truncatulina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 279; genotype, most typical species, here designated, *Cibicides refulgens* Montfort, not *Nautilus lobatulus* Walker and Jacob, as stated by Cushman, 1915, which was not in d'Orbigny's original list of species; both *Cibicides* and *Truncatulina* were founded on the same figure by Soldani.—Carpenter, Introd. Foram., 1862, p. 201, fig. 32 *E*.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 658.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 30.

Lobatula FLEMING, Hist. Brit. Anim., 1828, p. 232.

Heterolepa FRANZENAU, Termés. Füzetek, vol. 8, 1884, p. 181. Genotype *Rotalina dutemplei* d'Orbigny.

Pseudotruncatulina ANDREAE, Abh. geol. Specialkarte Elsass-Loth., vol. 2, pt. 3, 1884, p. 213, pl. 8, fig. 10. Genotype *Rotalina dutemplei* d'Orbigny.

Description.—Test free or attached to plants by the dorsal side, rotaloid, spire visible on the dorsal side, only the last whorl visible on the ventral side; ventral side usually the more convex, even conical, and umbilicate, dorsal side usually flat; chambers numerous, closely appressed, all alike or the last one much the largest; wall hyaline, coarsely perforate, smooth or with limbate sutures or secondary thickening; aperture a curved slit at the base of the last chamber, on the periphery, extending toward the umbilicus on the ventral side and also continuing on the dorsal side for a short distance along the suture line between the last two whorls, which is characteristic of the genus. Diameter, up to 1.5 mm.

CIBICIDES CONOIDEUS, n. sp.

Plate 10, fig. 7

Description.—Test plano-convex, nearly circular in side view, ventral side very high, with an umbo of clear shell material, periphery narrowly rounded, not carinate; chambers about twelve in the last whorl, increasing very gradually in size; sutures slightly limbate and gently curved on both sides, the last three slightly depressed on the dorsal side, others flush with the surface; wall coarsely perforate, the pores being at the base of conical pits, on the dorsal side partially covered by a smooth secondary thicking; aperture a small opening on the periphery, and extending along the suture line between the last two whorls on the dorsal side for a distance of two or three chambers.

Diameter of the type specimen, 0.48 mm.; height, 0.32 mm.

Holotype.—Columbia University Paleo. Coll. No. 19796, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Common in the middle and rare in the upper and the lower bed at the D. M. S. & B. Quarry. Rare in the Pliocene at Timms Point, San Pedro, California.

This species is characterized by its high conical shape and umbonate umbilical region. It is in addition readily distinguished from *Cibicides reflugens* Montfort, with which Bagg evidently confused the Timms Point forms (U. S. G. S. Bull. 513, 1912, p. 83, no figure), by its rounded periphery and greater number of chambers.

CIBICIDES FLETCHERI, n. sp.

Plate 10, figs. 8, 9

Description.—Test attached to plants in life and sometimes slightly distorted, plano-convex, dorsal side slightly concave, ventral convex and typically with an umbo of clear shell material, oval in side view, slightly lobulate, periphery moderately sharp; chambers about twelve in the last coil, increasing rapidly in size; sutures curved on both sides, broadly limbate dorsally; wall coarsely perforate, the perforations being at the bottom of conical depressions some of which on the ventral side are conspicuously larger than others; aperture an arched opening on the periphery not far produced ventrally but on the dorsal extending along the suture between the last two coils for a distance of four or five chambers, provided with a distinct lip.

Diameter of the type specimen, 0.65 mm.; height, 0.15 mm.

Holotype.—Columbia University Paleo. Coll. No. 19797, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Common in all three beds at the D. M. S. & B. Quarry. The umbonate forms are rather rare in the Pliocene of Timms Point, San Pedro, California, while specimens which are otherwise identical are quite common. Rare in well samples from the Saugus of the Los Angeles Basin.

This species differs from *C. conoideus*, n. sp. by the lesser convexity of the ventral side, the more rapidly enlarging chambers and the greater limbation of the sutures. It differs from *C. variolata* (d'Orbigny) (Foram. Foss. Vienne, 1846, p. 170, pl. 6, figs. 27–29) by the greater number of chambers and the presence of an umbo. Figure 9 shows a distorted individual.

This species is named for Mr. Corbin D. Fletcher.

CIBICIDES LOBATUS (d'Orbigny)

Plate 11, fig. 1

Truncatulina lobata D' ORBIGNY, Hist. Nat. Îles Canaries, 1839, vol. 2, pt. 2, Foraminifères, p. 134, pl. 2, figs. 22–24.

Description.—Test attached to plants in life, low plano-convex, dorsal side slightly concave, ventral slightly depressed in the umbilical region, periphery lobulate, provided with a slight rounded keel; chambers seven in the last whorl, regu-

larly increasing in size; sutures distinct, depressed, curved; wall fairly coarsely perforate throughout; aperture on the periphery at the base of the last chamber and extending onto the dorsal side along the suture line between the last two whorls for a distance of one or two chambers, with a distinct lip of clear shell material.

Diameter of the figured specimen, 0.60 m.; height, 0.15 mm.

Occurrence.—Rare in the lower and the middle bed and very rare in the upper bed at the D. M. S. & B. Quarry. Common in the Pliocene of Timms Point, San Pedro, California.

This species differs from *C. fletcheri*, n. sp. by the absence of the pits at the outer ends of the perforations and by its flatter test. The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

CIBICIDES MCKANNAI, n. sp.

Plate 10, figs. 5, 6

Description.—Test unequally biconvex, the ventral side more so, umbonate, periphery angled, very slightly lobulate; chambers numerous, ten to twelve in the last whorl; sutures on the dorsal side much curved and in the adult thickened with clear shell material which extends over the umbo obscuring the earlier chambers and sutures and closing many of the pores, sutures on the ventral side of clear shell material, very slightly depressed, the outer ends curved and the inner straight extending into the umbo which is also of clear shell material; wall coarsely perforate, many of the perforations on the dorsal side being closed by secondary shell material leaving others conspicuously larger than the average; aperture on the periphery extending a short distance toward the ventral umbo and normally extending along the suture line between the last two whorls on the dorsal side for a distance of one or two chambers.

Diameter of the type specimen, 0.50 mm.; thickness, 0.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19799, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds in the D. M. S. & B. Quarry. Very rare in the Pliocene at Timms Point, San Pedro, California. One specimen was found in some Recent material from 73½ fathoms, off the coast near Redondo, Los Angeles County, California. This species is rare in well samples from the Saugus; abundant in Upper Pico; and very abundant in Lower Pico well samples from the Los Angeles Basin. The specimens from the Upper Pico are usually larger in size than those from the Lower. In general they range from 0.25 mm. to 0.50 mm. in diameter, whereas those from the Lower Pico average from 0.15 mm. to 0.25 mm.

This species differs from *C. floridana* (Cushman) (U. S. G. S. Bull. 676, 1918, p. 62, pl. 19, fig. 2) by the lack of raised sutures on the ventral side. It shows considerable variation both as to the degree of convexity and the size and thickness of the test. The secondary shell material is not as well developed in the Lomita forms as in the more typical well specimens. Figure 6 shows a young specimen. Forms

evidently belonging to this species have been referred by various authors to *C. ungeriana* (d'Orbigny).

This species is named for Mr. E. A. McKanna, who has done much to further the study and application of micropaleontology.

CIBICIDES TENUIMARGO (H. B. Brady)

Plate 10, fig. 10

Truncatulina tenuimargo H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 662, pl. 93, figs. 2, 3.

Description.—Test attached by the dorsal side, rotaliform, convex ventrally and umbilicate, flattened dorsally, periphery keeled; chambers about fourteen, six or seven in the last whorl; sutures curved, limbate and flush with the surface dorsally, curved, depressed and radial ventrally; wall smooth, hyaline, coarsely perforate; aperture on the periphery and extending along the suture between the whorls on the dorsal side for a distance of several chambers.

Diameter of the figured specimen, 0.7 mm.; thickness, 0.27 mm.

Occurrence.—A single specimen was found in the lower bed at the D. M. S. & B. Quarry. Brady's specimens are Recent.

Genus PLANULINA d'Orbigny, 1826

Genotype (first species, here designated) *P. ariminensis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 280, pl. 14, figs. 1–3; Model No. 49. (Recent, Adriatic Sea, near Rimini.)

Description.—Test free, planispiral, rather flat, slightly evolute, the spire visible on both sides; chambers numerous, closely appressed, much curved; sutures usually limbate; wall hyaline, coarsely perforate; aperture a curved slit partially on the periphery and extending on the dorsal side for a short distance between the last two whorls.

This genus differs from *Anomalina* in the flatter form and extension of the aperture on the dorsal side; from *Cibicides* by the slightly evolute form and non-persistence of the aperture on the ventral side.

PLANULINA ARIMINENSIS d'Orbigny

Plate 11, fig. 2

Planulina ariminensis D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 280, pl. 14, figs. 1–3.

Description.—Test nearly planispiral, flattened, ventral side slightly convex, spire visible from both sides, periphery flat and provided with a slight double keel which becomes single on the last chamber and is present only on the dorsal side; chambers about ten in the last whorl; sutures curved, limbate, raised, highest in the early portion of the test; wall provided with large, circular depressions in the center of each of which is a large pore; aperture a large, arched opening, on the periphery toward the dorsal side and continuing along the suture line between the last two coils from a distance of two or three chambers.

Diameter of the figured specimen, 0.45 mm.; thickness, 0.10 mm.

Occurrence.—Rather common in all three beds at the D. M. S. & B. Quarry and

in the Pliocene of Timms Point, San Pedro, California. It has been noted in a few well samples from the Saugus and some from the Upper Pico of the Los Angeles Basin.

The Lomita and Timms Point specimens are about twice as thick as those shown by d'Orbigny's figures, but are otherwise very similar. The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

Family ACERVULINIDAE Schultze, 1854

Genus ACERVULINA Schultze, 1854

Genotype (first species, here designated) *A. inhaerens* SCHULTZE, Organismus Polythal., 1854, p. 67, pl. 6, fig. 12. (Recent, shallow water, near Ancona, Italy.)—MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, vol. 10, 1878, p. 171.

Gypsina CARTER (genotype, monotypical, *Gypsina melobesioides* CARTER, synonym of *Polytrema planum* Carter), Ann. Mag. Nat. Hist., ser. 4, vol. 20, 1877, p. 172; *ibid.*, ser. 5, vol. 5, 1880, p. 444.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 716.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 74 (the type cannot be *Orbitolina vesicularia* Parker and Jones.)

Aphorosina CARTER (genotype, monotypical, *A. informis* Carter), Jour. Roy. Micr. Soc., vol. 2, 1879, p. 500, pl. 17 *a*, figs. 5–11.

Description.—Test attached to plants or hard objects, or free and overgrowing itself, consisting of a mass of irregularly arranged, inflated chambers, with a small, coiled nucleoconch; walls calcareous, coarsely perforate, smooth, with little or no secondary tissue or structures, no canal system, and no oral aperture. Diameter, up to 1.5 mm. This genus evolved from *Cibicides* by loss of the regular, coiled form.

ACERVULINA INHAERENS Schultze

Plate 11, fig. 3

Acervulina inhaerens SCHULTZE, Organismus Polythal., 1854, p. 68, pl. 6, fig. 12.
Gypsina inhaerens H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 718, pl. 102, figs. 1–6.

Description.—Test attached to plants or other objects in life, consisting of a nearly circular mass or an irregular patch of irregularly arranged, rather closely appressed, hemispherical chambers, which mask the small, coiled nucleoconch; walls smooth, coarsely perforate; no oral aperture visible.

Diameter of figured specimen, 0.9 mm.

Occurrence.—Two specimens of this species were found in the lower bed of the D. M. S. & B. Quarry. They are identical in form with those figured by Brady (*op. cit.*).

Genus RUPERTIA Wallich, 1877

Genotype (monotypical) *R. stabilis* WALLICH, Ann. Mag. Nat. Hist., ser. 4, vol. 19, 1877, p. 502, pl. 20, figs. 1–13. (Recent, off Greenland.)—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 680.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 49.

Description.—Test attached by a large basal disc and rising into a columnar or bulbous coil; chambers fairly numerous, early ones close coiled, later ones elongate vertically and coiled in an elongate spire; wall calcareous, coarsely per-

forate, thick, with secondary deposit or attached foreign material; aperture an elongate slit at the inner edge of the last chamber. Height, about 2 mm.

RUPERTIA STABILIS Wallich

Plate 11, fig. 4

Rupertia stabilis WALLICH, Ann. Mag. Nat. Hist., ser. 4, vol. 19, 1877, p. 501, pl. 20.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 680, pl. 98, figs. 1–12.—FLINT, Rep. U. S. Nat. Mus. 1897 (1899), p. 336, pl. 79, fig. 4.—CUSHMAN, U.S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 50, pl. 21, figs. 2–5.

Description.—Test attached by the dorsal surface which shows the remnants of the characteristic coil and the dorsal portion of the aperture of *Cibicides*, expanding to form a flat base and rising into a short column; chambers broad, closely appressed, about eight in the last formed coil; sutures slightly depressed; wall smooth, coarsely perforate; aperture large, opening into the umbilicus on the upper or ventral side of the test and provided with a prominent tooth.

Length of the figured specimen, 0.8 mm.; width, 0.7 mm.

Occurrence.—Rare in the lower bed at the D. M. S. & B. Quarry. It was not present in the Timms Point Pliocene material we have examined. It is typically a Recent species and has been described by various authors.

Family VERNEUILINIDAE Cushman, 1927

Genus GAUDRYINA d'Orbigny, 1839

Genotype (first species named, designated by Cushman, 1911) *G. rugosa* D'ORBIGNY, Hist. Phys. Pol. Nat. Cuba, 1839, Foraminifères, p. 109, no species; Mém. Soc. Géol. France, ser. 1, vol. 4, 1840, p. 43, pl. 4, figs. 20, 21. (Top of the Upper Cretaceous, Meudon, France.)—D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 197, spelled "*Gaudrina*" and "*Gaudryna*."—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 377.—CHAPMAN, Foraminifera, 1902, p. 170.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 62; Bull. 104, pt. 3, 1922, p. 67.

Plectina MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, vol. 10, 1878, p. 160.

Description.—Test free, elongate; early chambers triserially spiral, later ones biserial; wall arenaceous; aperture a transverse slit at or near the base of the last septal face, often with raised border. Length, up to 5 mm., usually about 1 mm.

GAUDRYINA ARENARIA, n. sp.

Plate 11, fig. 5

Description.—Test elongate, initial end bluntly pointed, early triserial portion triangular with blunt carinate edges and somewhat concave sides, the later biserial portion subrectangular in end view; chambers narrow and closely appressed; sutures very indistinct; wall in the Lomita specimens very rough and coarsely arenaceous, in unweathered specimens more smoothly finished; aperture a small arched opening at the base of the inner margin of the last chamber.

Length of the type specimen, 0.8 mm.; width of apertural face, 0.3 mm.

Holotype.—Columbia University Paleo. Coll. No. 19812, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in the middle bed at the D. M. S. & B. Quarry. Rare in some

Recent material from 73½ fathoms near Redondo, Los Angeles County, California. A single specimen was noted in the Timms Point Pliocene material which we have. It is rare in many well samples from the Saugus of the Los Angeles Basin.

This form is characterized by its coarse texture, indistinct sutures and triangular triserial portion, which in the type specimen composes about one-half of the test. It differs from *G. triangularis* Cushman (U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 65, figs. 104 *a–c*) which it somewhat resembles in its triserial portion, by its non-inflated chambers, indistinct sutures, and small arched aperture. It differs from *G. jacksonensis* Cushman (Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 2, 1926, p. 33, pl. 5, fig. 1) by the quadrangular later portion, coarser texture, and smaller aperture.

GAUDRYINA GRAMMOSTOMATA, n. sp.

Plate 11, fig. 6

Description.—Test triangular in side view, enlarging rapidly, about two-thirds as broad as long, the triserial portion round and composing about one-fourth of the test; chambers closely appressed and not inflated except for the last two; sutures shallow and inconspicuous; wall finely arenaceous; aperture a long narrow slit slightly above the last suture line, surrounded by a narrow raised lip and, in the adult, sometimes partially closed at the middle by a small tooth-like process.

Length of the type specimen, 1.00 mm.; width at the apertural end, 0.60 mm.

Holotype.—Columbia University Paleo. Coll. No. 19813, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in the lower bed at the D. M. S. & B. Quarry. It was not found in the Timms Point Pliocene material examined but is present in well samples from the Saugus of the Los Angeles Basin.

Several closely allied species have been described by authors. This form differs from *Gaudryina baccata* Schwager (*Novara*-Exped., Geol. Theil., p. 2, 1866, p. 200, pl. 4, figs. 12 *a*, *b*) through lack of the angular chambers; from *Gaudryina bradyi* Cushman (U. S. Nat. Mus. Bull. 104, pt. 3, 1922, p. 74, pl. 12, fig. 8) by the long narrow character of the aperture; and from *Gaudryina chilostoma* Reuss (Denkschr. Ak. Wiss. Wien, Math.-Naturw. Cl., vol. 25, 1866, p. 120, pl. 1, fig. 5) both by the longer triserial portion and the long narrow character of the aperture.

Family HETEROHELICIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

Genotype (first species, designated by Cushman, 1911) *B. plicata* D'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, 1839, Foraminifères, p. 61, pl. 8, figs. 4–7. (Recent, off Valparaiso, Chile, great depth.)—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 416.—CHAPMAN, Foraminifera, 1902, p. 173.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 31; Bull. 104, pt. 3, 1922, p. 29.

Grammostomum EHRENBERG, Abh. k. Ak. Wiss. Wien, Phys.-Math. Cl., for 1838, 1840, p. 119 and table 1.

Brizalina COSTA, Atti Accad. Pontaniana, vol. 7, fasc. 1, pt. 2, 1853 (1856), p. 296.

Description.—Test free, elongate, flattened; chambers biserial, the two series showing on the flattened sides, closely appressed, edges of test usually angled, sometimes flanged or spinose; wall calcareous, thin, hyaline, finely perforate; aperture at the base of the last chamber, elongate in the direction of flattening of the test (differing from *Gümbelina*); surface smooth or ornamented with striae, costae, knobs, spines, puncta, etc. Length, average about 0.6 mm., up to 1.5 mm.

BOLIVINA INTERJUNCTA Cushman

Plate 11, figs. 10–13

Bolivina costata D'ORBIGNY, var. *interjuncta* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 2, 1926, p. 41, pl. 6, fig. 3.

Description.—Test elongate, gradually tapering from the initial end which is sharply pointed in the microspheric form and broadly rounded in the megalospheric, compressed and provided with a sharp keel which bifurcates and runs along the edges of the last two chambers, and further ornamented with four costae on the initial end which increase by bifurcation and by development from the keel in the middle portion of the test and decrease by fusion toward the proximal end; transversely the costae are connected in an irregular manner by raised partitions more or less coinciding with the suture lines; chambers very narrow and numerous, in the microspheric form about fifteen to twenty on a side, and in the megaspheric about ten on a side; sutures arched and raised; wall finely and conspicuously perforate; aperture a narrow vertical slit on the flat septal face surrounded by a slightly raised border.

Length of the adult figured specimens, megaspheric 0.8 mm., microspheric 1.0 mm.; width, megaspheric 0.37 mm., microspheric 0.36 mm.

Topotypes.—Columbia University Paleo. Coll. No. 19776–19779, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Abundant in the lower and rare in the middle and upper beds at the D. M. S. & B. Quarry. Cushman records its presence in the Upper and Middle Fernando of Ventura County, California, and at Timms Point, Santa Barbara County. It is probable that Timms Point, San Pedro, Los Angeles County, California, is the latter locality meant by Cushman, although we did not find it in any of our material from there. This variety is rare in well samples from the Saugus and common in those from the Upper Pico of the Los Angeles Basin.

This species is not, as considered by Cushman, a variety of *B. costata* d'Orbigny (Voy. Amér. Mérid., vol. 5, pt. 5, Foraminifères, 1839, p. 62, pl. 8, figs. 8, 9), which is round on the edges, has six costae on a side, no keel, a nearly smooth last chamber, and a produced aperture. Figures 10 and 11 show an adult specimen from the lower bed. Figures 12 and 13 show a young megaspheric specimen from the middle bed which has only the four initial costae, and a young microspheric form from the lower bed.

BOLIVINA LOMITENSIS, n. sp.

Plate 11, fig. 7

Description.—Test elongate, gradually tapering from the broadly rounded initial end, somewhat compressed, edge rounded; chambers narrow, arched, about ten on a side; sutures slightly limbate, not raised; wall smooth, finely perforate; aperture an elongate slit with a very narrow border.

Length of the type specimen, 0.55 mm.; width, 0.28 mm.

Holotype.—Columbia University Paleo. Coll. No. 19775, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Very rare in the middle bed at the D. M. S. & B. Quarry.

This species differs from *B. argentea* Cushman (Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 2, 1926, p. 42, pl. 6, fig. 5) by its thicker test, more rounded periphery, and the absence of raised sutures. It differs from *B. spissa* Cushman (*op. cit.*, p. 45, pl. 6, figs. 8 *a*, *b*.) by its rounded periphery, absence of costae on the megaspheric proloculum, and lack of raised sutures.

BOLIVINA MODESTA, n. sp.

Plate 11, fig. 8

Description.—Test elongate, tapering gradually from the rounded apical end, compressed, the edges rounded; chambers about fourteen on a side, closely appressed; sutures nearly straight, distinct, very slightly depressed; wall calcareous, finely perforate; aperture elongate.

Length of the type specimen, 0.45 mm.; width, 0.22 mm.

Holotype.—Columbia University Paleo. Coll. No. 19780, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—This species is very rare in the middle bed at the D. M. S. & B. Quarry. It was not found in the Timms Point Pliocene material examined.

This *Bolivina* lacks any sharply distinguishing characters other than the straight suture lines.

BOLIVINA SINUATA, n. sp.

Plate 11, fig. 9

Description.—Test elongate, tapering slightly from the bluntly rounded initial end in the megaspheric form and the pointed initial end in the microspheric form; early portion somewhat compressed, later broadly rounded and more or less flattened on the sides and edges; provided with four rather high, rounded and thick costae which tend to be discontinuous at the sutures and rapidly develop into rows of sinuate lobes or knobs on the later portions of the test; at the same time the suture lines tend to develop a lobated character and connect the rows of lobes; chambers about ten in the megaspheric form and more numerous in the microspheric; wall finely but distinctly perforate; aperture a highly arched opening at the inner margin of the last chamber.

Length of the type specimen, 0.89 mm.; width, 0.34 mm.

Holotype.—Columbia University Paleo. Coll. No. 19781, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Very rare in the lower and the middle beds and rare in the upper bed at the D. M. S. & B. Quarry. A single imperfect specimen was found in the Pliocene of Timms Point, San Pedro, California. A few specimens have been found in well samples from the Saugus of the Los Angeles Basin. It is very rare in well samples from the Upper Pico, fairly common in those from the Lower Pico, and rather abundant in those from the Puente of the Basin. It is likewise fairly abundant in the Miocene clay or mud bounders which were found in the D. M. S. & B. Quarry deposit.

This species is characterized by the rows of sinuate lobes and the lobated sutures. It differs from *D. decussata* H. B. Brady (Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 423, pl. 53, figs. 12, 13), which it most nearly resembles, by the broadly rounded outline of its less compressed test, its more regular arrangement of the lobes in rows, and the absence of a truncated apertural end. Many of the lower well specimens are of a more primitive ancestral type, having well-developed, sharp, bifircating costae on the lower portion of the test which become rounded, break up, and tend toward lobation which is fully developed on the later one-fourth to one-half of the test; while the early sutures, which are arched, tend to become raised and on the latest portion form connecting lobes.

BOLIVINA SPISSA Cushman

Plate 11, figs. 14–16

Bolivina subadvena CUSHMAN, var. *spissa* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 2, 1926, p. 45, pl. 6, figs. 8 *a*, *b*.

Description.—Test compressed, thickened along the median portion, tapering gradually from the sharply pointed apical end to the broad apertural end in the microspheric form and enlarging rapidly from the rounded initial end in the megalospheric form; periphery acute, slightly carinate, the initial end occasionally with a slight apical spine; chambers about eight or nine pairs, arched, not inflated; sutures distinct, limbate, slightly raised along the median portion of the adult test; wall with distinct medium-sized perforations, smooth except for traces of costae on the megaspheric proloculum; aperture an arched slit at the base of the septal face of the last chamber.

Length of the figured specimens, megaspheric 0.6 mm. and 0.5 mm.; microspheric 0.7 mm.; width, megospheric 0.27 mm. and 0.25, microspheric 0.26 mm.

Occurrence.—Very rare in all three beds at the D. M. S. & B. Quarry and in the Timms Point Pliocene. Fairly common in well samples from the lower part of the Saugus, and very abundant in those from the Upper Pico of the Los Angeles Basin. Cushman states that his type is from the Pliocene of Timms Point, Santa Barbara, California. It is probable he meant Timms Point, San Pedro, Los Angeles County, California.

This species is not a variety of *B. subadvena* Cushman from which it differs by its regular, arched, non-inflated chambers, limbate sutures, more compressed form, acute periphery and smaller perforations. The figured specimens are from the lower and middle beds at the D. M. S. & B. Quarry.

Family BULIMINIDAE Jones, 1876

Genus BULIMINA d'Orbigny, 1826

Genotype (designated by Cushman, 1911) *Bulimina marginata* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 269, pl. 12, figs. 10–12. (Recent, Adriatic, near Rimini.)—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 397.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 76; Bull. 104, pt. 3, 1922, p. 90.

Description.—Test free, tapering, high-spired; chambers numerous, inflated, usually three to a volution; wall calcareous, hyaline, finely perforate; surface smooth or costate or spinose; aperture comma-shaped, broadest above, nearly vertical, extending from the last suture up into the last septal face, sometimes with vertical, plate-like tooth. Length, up to 1 mm.

BULIMINA MARGINATA d'Orbigny

Plate 11, fig. 17

Bulimina marginata D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 269, No. 4, pl. 12, figs. 10–12.

Description.—Test ovate, somewhat tapering, composed of about five or six whorls, initial end provided with a short spine; chambers numerous, inflated, the lower margin of each extending out from the preceding at a sharp angle forming a definite thickened rim which has fine, short, downward extending spines producing a more or less serrate edge; sutures distinct, depressed; wall smooth, very finely perforate; aperture a comma-shaped slit situated in a slight depression of the inner face of the last chamber.

Length of the figured specimen, 0.44 mm.; diameter, 0.25 mm.

Occurrence.—Very rare in all three beds at the D. M. S. & B. Quarry. Not present in the Timms Point material which we have. Its occurrence in Recent ocean deposits has been noted by many authors. Common in some well samples from the Saugus of the Los Angeles Basin.

The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

Genus GLOBOBULIMINA Cushman, 1927

Genoholotype *Globobulimina pacifica* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 67, pl. 14, fig. 12. (Recent, eastern Pacific, 1197 fathoms.)

Description.—Test free, ovate, spiral, three chambers to a whorl, the last whorl nearly or quite embracing the earlier whorls; chambers longer than wide; wall calcareous, hyaline, thin, finely perforate; aperture comma-shaped, with vertical tooth which extends down to the preceding chamber. Length, up to 1 mm.

GLOBOBULIMINA PACIFICA Cushman

Plate 11, fig. 18

Bulimina pyrula H. B. BRADY (not d'Orbigny), Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 399, pl. 50, figs. 7–10.—BAGG, U. S. G. S. Bull. 513, 1912, p. 39, pl. 9, figs. 1 *a–e*.

Globobulimina pacifica CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 67, pl. 14, fig. 12.

Description.—Test elongate, pyriform in side view, broadest near the base, nearly circular in end view, apical end rounded; chambers embracing, the visible ones few, very little inflated; sutures only slightly depressed; wall smooth, translucent, very thin, very finely perforate; aperture an elongate comma-shaped slit surrounded by a more or less distinct lip and partially closed by a broad plate-like tooth.

Length of figured specimen, 0.60 mm.; diameter, 0.38 mm.

Occurrence.—Very rare in the lower bed at the D. M. S. & B. Quarry and in the Pliocene at Timms Point, San Pedro, California. Rare in well samples from the Saugus and the Upper Pico of the Los Angeles Basin. Common in those from the Lower Pico. Abundant in the Miocene clay or mud boulders in the northern end of the D. M. S. & B. Quarry. Brady's specimens are Recent.

This and similar forms have been classified by various authors as *B. pyrula* d'Orbigny (Foram. Foss. Vienne, 1846, p. 184, pl. 11, figs. 9–10). It differs from the latter by its thinner and more elongate test which is circular in cross-section, its more involute method of coiling, and the less inflated chambers. Perfect well specimens are hard to find owing to the fragile and pyritized condition of the test. The figured specimen is from the lower bed at the D. M. S. & B. Quarry.

Family UVIGERINIDAE, n. fam.

Genus UVIGERINA d'Orbigny, 1826

Genotype (first species figured, designated by Cushman, 1913) *U. pigmea* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 268, pl. 12, fig. 8; Model No. 67. (Pliocene, near Siena, Italy.)—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 573.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 91; Bull. 104, pt. 4, 1923, p. 160.

Uhligina SCHUBERT, Sitz. naturw.-med. Ver. Böhmen, "Lotos," Prag, 1899, p. 222, pl. 5, fig. 2.

Description.—Test free, conical, subcylindrical or fusiform, round or flattened in cross-section, high-spired, triserial, rarely biserial, becoming less regular toward the final chamber; chambers numerous, somewhat inflated, more closely appressed at the initial end; wall calcareous, hyaline, very finely perforate, smooth, plicate, striate, spinose, or some combination of two or more of those forms of ornamentation, the ornamentation tending to break up or be lost toward the apertural end; aperture terminal, a small tube usually with phialine lip. Length, up to 1 mm. or more.

UVIGERINA AUBERIANA d'Orbigny

Plate 11, fig. 22

Uvigerina auberiana D'ORBIGNY, De la Sagra, Hist. Phys. Pol. Nat. Cuba, 1839, Foraminifères, p. 106, pl. 2, figs. 23, 24.

Description.—Test fusiform, about five whorls; chambers numerous, inflated; sutures distinct, depressed; wall covered by short, stout spines; aperture situated at the end of a short neck surrounded by a phialine lip.

Length of the figured specimen, 0.55 mm.; diameter, 0.28 mm.

Occurrence.—Very rare in the middle bed from the D. M. S. & B. Quarry and in the Pliocene of Timms Point, San Pedro, California. It is very rare in well samples from the Saugus and the Upper Pico of the Los Angeles Basin. The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

UVIGERINA BAGGI, n. sp.

Plate 11, fig. 19

Description.—Test short, thick, fusiform, lower half conical, tapering abruptly from the short initial end, later half triangular, with slightly concave sides; chambers few, the last three composing one-half of the test, slightly inflated; sutures distinct, not depressed, of clear shell material; wall smooth, very finely perforate; aperture situated at the end of a fairly short neck with a phialine lip.

Length of the type specimen, 0.45 mm.; diameter, 0.28 mm.

Holotype.—Columbia University Paleo. Coll. No. 19863, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Very rare in all three beds in the D. M. S. & B. Quarry and in the Pliocene of Timms Point, San Pedro, California. Rare in well samples from the Saugus of the Los Angeles Basin.

This species is readily distinguished by its short, conical initial and later triangular character with slightly concave sides.

UVIGERINA FARINOSA Hantken

Plate 11, fig. 20

Uvigerina farinosa Hantken, Mitt. Jahr. Kon. Ungar., Geol. Anst., vol. 4, p. 62, pl. 7, fig. 6.

Description.—Test elongate, cylindrical, composed of about five whorls; chambers numerous, somewhat inflated; sutures distinct, depressed; wall smooth, very finely perforate; aperture round, at the end of a moderately long neck which is provided with a phialine lip.

Length of the figured specimen, 0.65 mm.; diameter, 0.20 mm.

Occurrence.—Very rare in the lower bed at the D. M. S. & B. Quarry and in the Pliocene at Timms Point, San Pedro, California. Very rare in well samples from the Saugus of the Los Angeles Basin. Hantken's type is from the Lower Oligocene of Hungary.

UVIGERINA HUGHESI, n. sp.

Plate 12, fig. 5

Description.—Test fusiform, subtriangular in cross-section in the later portion, early portion conical; chambers numerous, early ones inflated, later ones flattened so as to produce a triangular outline; sutures distinct, depressed; wall smooth, the apical end in some specimens provided with a few obscure costae; aperture terminal, oval, with a thickened lip and very short neck.

Length of the type specimen, 0.48 mm.

Holotype.—Columbia University Paleo. Coll. No. 19865 from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Very rare in all three beds at the D. M. S. & B. Quarry and in the Timms Point Pliocene. Rare in well samples from the Saugus of the Los Angeles Basin.

This species is probably that identified by Bagg as *U. angulosa* Williamson after Goës (U. S. G. S. Bull. 513, 1912, p. 75, pl. 22, figs. 2 *a–f*). It differs from *U. angulosa* Williamson (Recent Foram. Great Britain, 1858, p. 67, pl. 5, fig. 140) in the less triangular outline and the more fusiform shape of the test, the more inflated character of the chambers and the absence of the characteristic costae.

This species is named for Mr. D. D. Hughes.

UVIGERINA PEREGRINA Cushman

Plate 12, figs. 1, 2

Uvigerina peregrina CUSHMAN, U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 166, pl. 42, figs. 7–10.

Description.—Test fusiform, elongate, about two and one-half times as long as broad, maximum width just above the middle; chambers numerous, inflated; sutures depressed and more or less indistinct; ornamented with nine rows of high costae which are not continuous beyond the sutures, which are highest in the central portion of the test and tend to fade out near the apertural end; wall between costae somewhat granular, very finely perforate; aperture at the end of a short neck surrounded by a phialine lip.

Length of the adult figured specimen, 0.75 mm.; diameter, 0.38 mm.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Very rare in the Pliocene at Timms Point, San Pedro, California. This species is rare in well samples from the Saugus, very abundant in those from the Upper Pico and rare in those from the Lower Pico of the Los Angeles Basin. It is a good guide-fossil for the Upper Pico of the Basin. Cushman's type is Recent, from the Atlantic Ocean.

The California form differs from Chusman's type in the shorter and smoother character of the neck. The figured specimens are from the middle bed at the D. M. S. & B. Quarry. Figure 2 shows a submature specimen.

UVIGERINA PEREGRINA Cushman, var. PARVULA Cushman

Plate 12, figs. 3, 4

Uvigerina peregrina parvula CUSHMAN, U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 168, pl. 42, fig. 12.

Description.—Test short, conical, formed of about four whorls; chambers few, inflated; sutures depressed, of clear shell material, fairly distinct; wall ornamented

by six to seven moderately high broad costae to a side, which are not continuous beyond the suture lines of each chamber, and which are highest in the central portion of the test; aperture at the end of a very short neck with a phialine lip.

Length of the figured specimens, 0.27 mm. and 0.38 mm.; diameter, 0.17 and 0.25 mm.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Present in the Pliocene of Timms Point, San Pedro, California. Rare in well samples from the Saugus, abundant in those from the Upper Pico, and rare in those from the Lower Pico of the Los Angeles Basin. Cushman's type is Recent, from the Gulf of Mexico.

It is possible that this variety is merely a young stage of *U. peregrina* Cushman. The figured specimens are from the middle bed at the D. M. S. & B. Quarry. Figure 4 shows a young specimen.

UVIGERINA SEMITRIGONA, n. sp.

Plate 11, fig. 21

Description.—Test short, thick, fusiform, lower half conical, tapering abruptly from the sharp initial point in the microspheric form, later half triangular; chambers few, the last three composing one-half of the test, very slightly inflated; sutures distinct, slightly depressed, of clear shell material; wall ornamented with about ten rows of low costae to a side, which are not continuous beyond the sutures, very finely perforate; aperture at the end of a very short neck with a phialine lip.

Length of the type specimen, 0.43 mm.; diameter, 0.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19870, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry and in the Pliocene at Timms Point, San Pedro, California. This species is likewise rare in well samples from the Saugus of the Los Angeles Basin.

This species differs from *U. baggi*, n. sp. by the presence of the costae. It differs from *U. angulosa* Williamson (Rec. Foram. Great Britain, 1858, p. 67, pl. 5, fig. 140) by its short, thick, fusiform test with its conical early portion.

Family CASSIDULINIDAE d'Orbigny, 1846

Genus CASSIDULINA d'Orbigny, 1826

Genotype (monotypical) *C. laevigata* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 282, pl. 15, figs. 4, 5; Model No. 41. (Recent, sand from ballast.)—CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 3, 1925, p. 51. (Summary of the genus.)

Description.—Test free, coiled planispirally at least in the early portion, usually involute, sometimes partially evolute; chambers numerous, biserial, alternating on the sides of the plane of coiling; sutures distinct; wall calcareous, hyaline, finely perforate, smooth, rarely ornamented, sometimes with keel or peripheral spines; aperture narrow, elongate, buliminoid, with slight modification in the different

species, simple or with flattened tooth partially closing the opening. Diameter, up to 1 mm.

CASSIDULINA CALIFORNICA Cushman and Hughes

Plate 12, figs. 6, 7

Cassidulina californica CUSHMAN AND HUGHES, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 12, pl. 2, fig. 1.

Description.—Test broadly oval in edge view with sides nearly parallel, ends broadly rounded, nearly circular in side view except for the somewhat projecting last-formed chamber, periphery in adults only slightly inflated; chambers alternating with five pairs forming the last whorl, slightly inflated and embracing to the center of the test; sutures distinct, nearly straight, slightly limbate but not raised; wall smooth, matt in surface specimens, hyaline in unweathered ones, very finely perforate; aperture a little to one side of and parallel to the general plane of coiling, provided on the chamber side with a projecting plate-like tooth partially filling the opening.

Length of the figured adult specimen, 1 mm.; thickness, 0.6 mm.

Occurrence.—Very rare in the lower, rare in the middle and rather common in the upper bed at the D. M. S. & B. Quarry. Very abundant in the Pliocene of Timms Point, San Pedro, California. Very abundant in well samples from the Saugus, common in those from the Upper Pico, and rare in those from the Lower Pico of the Los Angeles Basin. The Lower Pico forms are typically much smaller than the higher specimens. The type of Cushman and Hughes is from the Pliocene of San Pedro.

This species differs from *C. subglobosa* Brady (Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 430, pl. 54, figs. 17 *a–c*) by its less globular form and particularly in the position and character of the aperture, which in the latter species extends up into the face of the last septum at an angle of about 45° to the plane of coiling and lacks the tooth. Figure 6 shows an adult specimen from the upper bed and figure 7 a young specimen from the middle bed.

CASSIDULINA LIMBATA Cushman and Hughes

Plate 12, fig. 12

Cassidulina limbata CUSHMAN AND HUGHES, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 12, pl. 2, fig. 2.

Description.—Test nearly circular in side view, the last-formed chamber slightly projecting, provided with a central umbo of clear shell material; periphery slightly lobulate, carinate; six pairs of chambers in the last formed whorl, distinct, tibia-shaped, the central portion being the narrowest; sutures very distinct, broad and limbate; wall smooth, very finely perforate; aperture elongate and narrow, parallel to the plane of coiling, with a slight plate-like tooth.

Diameter of the figured specimen, 0.59 mm.; thickness, 0.54 mm.

Occurrence.—Fairly common in the lower bed and rare in the middle and upper bed. Very abundant in the Pliocene of Timms Point, San Pedro, California. Abundant in well samples from the Saugus of the Los Angeles Basin. A few rare speci-

mens have been noted in well samples from the Upper Pico. This form is much more abundant in the Saugus of the Basin than in the San Pedro. The type of Cushman and Hughes is from the Pliocene of Timms Point.

This species is readily recognized by its broad limbate sutures and characteristic tibia-shaped chambers. The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

CASSIDULINA LOMITENSIS, n. sp.

Plate 12, fig. 10

Description.—Test round in side view, broadly oval in edge view, with five pairs of smooth, non-inflated chambers, giving it a smooth, regular, non-lobulate outline; sutures distinct, limbate but not raised, slightly increasing in width toward the inner ends of the chambers which they tend to separate by stellate, clear shell material; wall smooth, very finely perforate; aperture parallel to the plane of coiling and partially filled by a plate-like tooth.

Diameter of the type specimen, 0.7 mm.; width, 0.5 mm.

Holotype.—Columbia University Paleo. Coll. No. 19791 from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Abundant in the lower bed and rare in the middle and the upper bed at the D. M. S. & B. Quarry. Very rare in the Pliocene of Timms Point, San Pedro, California. Rare in well samples from the Saugus, very rare in those from the Upper Pico, and rare to common in certain samples from the Lower Pico of the Los Angeles Basin. It is more typically a San Pedro species.

This species is characterized by its smooth, regular outline and non-inflated chambers, in which respect it differs from *C. californica* Cushman and Hughes. It is evidently a later development of the latter species.

CASSIDULINA LOMITENSIS var. ELEGANTULA new var.

Plate 12, fig. 9

Description.—This variety differs from the species in the greater number of chambers, there being seven in the last whorl, which do not meet in the umbonal region, the umbo being filled with clear shell material, through which earlier whorls are visible.

Diameter of the type specimen, 1.37 mm.; thickness, 0.75 mm.

Holotype.—Columbia University Paleo. Coll. No. 19792, from the lower bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. We have not found it in Timms Point material, nor in Saugus or Pico well samples.

CASSIDULINA QUADRATA Cushman and Hughes

Plate 12, fig. 8

Cassidulina subglobosa H. B. BRADY, var. *quadrata* CUSHMAN AND HUGHES, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 15, pl. 2, figs. 7 *a–c*.

Description.—Test nearly circular in side view, subquadrangular in apertural view, periphery not at all or only very slightly lobulate; chambers five or six pairs

in the final volution, closely appressed, not inflated; sutures distinct, limbate, very slightly depressed; wall smooth, matt in surface specimens, hyaline in well specimens, very finely perforate; aperture a more or less rounded elongate slit slightly to one side and parallel to the plane of coiling, usually partially filled by a plate-like tooth.

Diameter of the figured specimen, 0.75 mm.; thickness, 0.65 mm.

Occurrence.—Abundant in the lower and common in the middle and the upper bed at the D. M. S. & B. Quarry. Common in some well samples from the Saugus and rare in those from the Upper and the Lower Pico of the Los Angeles Basin. The Lower Pico specimens are typically much smaller than the higher specimens. The type specimen of Cushman and Hughes is from the D. M. S. & B. Quarry.

This species is closely related to *C. californica* Cushman and Hughes. It is not a variety of *C. subglobosa* Brady (Quar. Jour. Micr. Sci., vol. 21, 1881, p. 60; Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 430, pl. 54, figs. 17 *a–c*) from which it differs in the method of coiling and position of the aperture. The figured specimen is from the lower bed at the D. M. S. & B. Quarry.

CASSIDULINA REFLEXA, n. sp.

Plate 12, fig. 13

Description.—Test equally biconvex with a thick central umbo which, in unweathered specimens, is of clear shell material, broadly ovate in side view; periphery subacute; chambers about seven or eight pairs in the adult making in the last formed coil a distinct angle at the periphery, somewhat concave toward their central portion and terminating at the central umbo where they are bluntly rounded; sutures distinct, limbate but not raised; wall, in unweathered specimens, translucent to opaque, very finely perforate; aperture an elongate, comma-shaped slit parallel to the plane of coiling and partially filled by a plate-like tooth.

Length of the type specimen, 0.32 mm.; thickness, 0.18 mm.

Holotype.—Columbia University Paleo. Coll. No. 19794, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Common in the Pliocene of Timms Point, San Pedro, California. Common in well samples from the Saugus of the Los Angeles Basin.

This species may be distinguished from *C. tortuosa* Cushman and Hughes, which it most closely resembles, by its less tortuous chambers, which have a more concave middle portion and a more bluntly rounded or knob-like inner terminus.

CASSIDULINA TRANSLUCENS Cushman and Hughes

Plate 12, fig. 11

Cassidulina translucens Cushman and Hughes, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 15, pl. 2, fig. 5.

Description.—Test nearly circular in side view, lenticular in edge view, provided with a thin broad carina; chambers six or seven pairs in the last-formed whorl

which are only slightly overlapping, very distinctly rhomboidal, broadest at the base with long sides nearly parallel; sutures distinct but not marked at the surface; wall smooth, hyaline, transparent, particularly in the umbonal region where the earlier chambers and round proloculum are visible; aperture elongate, in the plane of coiling and provided with a very long, thin, narrow tooth.

Diameter of the figured specimen, 0.46 mm.; thickness, 0.22 mm.

Occurrence.—Abundant in the lower, common in the middle and rare in the upper beds at the D. M. S. & B. Quarry. Very rare in the Pliocene of Timms Point, San Pedro, California. Rare in well samples from the Saugus and very abundant in those from the Upper and the Lower Pico of the Los Angeles Basin. It is a good guide-fossil for the Pico of the Basin. The type of Cushman and Hughes is from the D. M. S. & B. Quarry.

The rhomboidal chambers, the thin, broad carina, and the translucent character of the test serve to distinguish the species. The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

FAMILY NONIONIDAE Reuss, 1860.

Genus NONION Montfort, 1808

Genoholotype *Nautilus incrassatus* Fichtel and Moll, Test. Micr., 1798, p. 38, pl. 4, figs. *a–c.* (Recent, Elba.)

Nonion Montfort, Conch. Syst., vol. 1, 1808, p. 211, text fig. copied from Fichtel and Moll.
Melonis Montfort, *ibid.*, p. 66.
Florilus Montfort, *ibid.*, p. 134.
Nonionina d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 293.

Description.—Test free, nautiloid, involute, biumbilicate, round on the back; chambers numerous, eight to twelve in the last whorl, closely appressed; walls hyaline, finely but distinctly perforate, smooth, sometimes with umbilical thickening; aperture a curved slit at the base of the last septal face on the inner periphery.

NONION SCAPHA (Fichtel and Moll)

Plate 12, fig. 14

Nautilus scapha FICHTEL AND MOLL, Test. Micr., 1798, p. 105, pl. 19, fig. *d–f.*

Description.—Test nearly bilaterally symmetrical, biumbilicate, embracing to the umbilicus in early portion and becoming very slightly evolute in the later, oval in side view, elongate oval in face view; periphery rounded, not keeled; chambers short and wide, not inflated, about twelve to thirteen in the last whorl; sutures curved, very slightly depressed; wall smooth, very finely perforate; aperture very narrow, without a raised border.

Length of the figured specimen, 0.68 mm.; width, 0.45 mm.

Occurrence.—Very rare in the lower, rare in the middle, and common in the upper bed at the D. M. S. & B. Quarry. Abundant in some Recent material from 63 fathoms and from 73½ fathoms from near Redondo, Los Angeles County,

California. Very rare in the Timms Point Pliocene. Common in well samples from the Saugus of the Los Angeles Basin.

The Lomita specimens are slightly more rounded on the periphery than the type figures of Fichtel and Moll, but in all other respects they resemble them much more closely than the figures of most succeeding authors who show specimens of much greater thickness than the type. The figured specimen is from the middle bed at the D. M. S. & B. Quarry.

Genus THEMEON Montfort, 1808

Genoholotype *Themeon rigatus* MONTFORT (renamed from *Nautilus crispus* Linné), Conch. Syst., vol. 1, 1808, p. 202, text figs. redrawn from Fichtel and Moll. Test. Micr., 1798, p. 40, pl. 4, figs. *d–f*. (Recent, Adriatic.)

Elphidium MONTFORT, *ibid.*, p. 14. Genoholotype *Nautilus macellus* Fichtel and Moll.
Geophonus MONTFORT, *ibid.*, p. 18. Type *N. macellus* F. & M.
Pelorus MONTFORT, *ibid.*, 22. Type *Nautilus ambiguus* F. &. M.
Andromedes MONTFORT, *ibid.*, p. 38. Type *Nautilus strigillatus* Fichtel and Moll.
Sporilus MONTFORT, *ibid.*, p. 42. Type *Nautilus strigillatus* F. & M., var. 2.
Cellanthus MONTFORT, *ibid.*, p. 206. Type *Nautilus craticulatus* F. & M.
Vorticialis LAMARCK, Extrait Cours Zoöl., 1812, p. 122. Type, first species included in the genus by Defrance, 1824, *Nautilus craticulata* F. & M.
Polystomella LAMARCK, Hist. Ann. s. Vert., vol. 7, 1822, p. 625. Genotype, designated by Cushman, 1914, *Nautilus crispus* Linné.
Helicoza MOEBIUS, Beitr. Meeres fauna Insel Mauritius, 1880, p. 103. One species, *H. craticulata* (F. & M.).
Geoponus EHRENBERG (*Geophonus* Montfort), Abh. k. Ak. Wiss. Berlin, Phys.-Math. Cl., 1839, p. 132.
Polystomatium EHRENBERG, *ibid.*, 1839, p. 132; *ibid.*, 1855, pp. 150, 171.

The name *Themeon* is here selected for this genus, in accordance with Article 28 of the International Rules of Zoölogical Nomenclature, since the nomenclature of the genus has not previously been revised.

Description.—Test free, lenticular, planispiral, equilateral; chambers numerous, closely appressed, embracing to the umbilical region, which frequently is filled with secondary tissue; wall finely perforate, smooth, with canal system which opens at the umbilicus and along the sutures by a single or double row of pores, frequently with a regular series of ridges connecting or crossing the sutures externally; aperture a curved slit or row of pores at the base of the septal face, or numerous pores on the septal face.

THEMEON CRISPUS (Linné)

Plate 12, fig. 17

Nautilus crispus LINNÉ, Syst. Nat., ed. 12, 1767, p. 1162.
Polystomella crispa LAMARCK, Anim. sans Vert., vol. 7, 1822, p. 625, No. 1.—D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 125, pl. 6, figs. 9–14.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 736, pl. 110, figs. 6, 7.—FLINT, Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 338, pl. 80, fig. 3.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 32, pl. 18. fig. 1.

Description.—Test lenticular, coiled in an involute nautiloid spire with twenty to twenty-five chambers composing the outer volution, periphery keeled, not

lobulate; sutures limbate, connected by numerous closely set septal bridges; the umbilical region umbonate, filled with clear shell material in which there are a few large, round pores; aperture a series of openings between the bridges along the base of the last chamber.

Diameter of the figured specimen, 0.75 mm.; thickness, 0.40 mm.

Occurrence.—Very abundant in all three beds at the D. M. S. & B. Quarry. Rare in the Pliocene at Timms Point, San Pedro, California. A common species in the Recent oceans.

The figured specimen is from the upper bed at the D. M. S. & B. Quarry. More mature specimens measure from 1.00 mm. to 1.80 mm.

THEMEON DECIPIENS, n. sp.

Plate 12, figs. 15, 16

Polystomella striato-punctata H. B. BRADY (not *Nautilus striato-punctatus* Fichtel and Moll), Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 733, pl. 109, fig. 22 (not. fig. 23).—BAGG, U. S. G. S. Bull. 513, 1912, p. 92, pl. 27, figs. 10, 11 (not fig. 12).

Description.—Test nautiloid, bilaterally symmetrical, periphery very slightly lobulate, broadly rounded in edge view; chambers few, about eight or nine in the last whorl, embracing nearly to the umbilicus which is filled with granular material; sutures slightly curved, slightly depressed and each provided with eight to ten small, indistinct, round pores; wall in the Lomita specimens granular; aperture a very narrow curved slit.

Diameter of the type specimen, 0.22 mm.

Holotype.—Columbia University Paleo. Coll. No. 19857, from the middle bed at the D. M. S. & B. Quarry.

Occurrence.—Rare in all three beds at the D. M. S. & B. Quarry. Rare to common in the Pliocene at Timms Point, San Pedro, California.

This species has been identified by various authors as *Polystomella striato-punctata* (of Fichtel and Moll), yet a glance at Fichtel and Moll's original figures (Test. Micr. 1798, p. 61, pl. 9, figs. *a–c*) will show that they are entirely different. It seems very probable that the form which Bagg describes and figures as *Nonionina depressula* (U. S. G. S. Bull. 513, 1912, p. 88, pl. 28, figs. 7, 8) and which he states is exactly similar to his *Polystomella striato-punctata* is this same species and that Bagg overlooked the pores. Figure 16 shows a more lobulate individual, from the middle bed.

TABLE II

TABLE SHOWING THE RANGES OF THE LOMITA D. M. S. & B. QUARRY PLEISTOCENE FORAMINIFERA IN THE LOS ANGELES BASIN

R = rare, C = common, A = abundant, X = present.

	PLEISTOCENE			PLIOCENE				MIOCENE
	LOWER SAN PEDRO			FERNANDO				
	D. M. S. & B. QUARRY			SAUGUS		PICO		
	Upper Bed	Middle Bed	Lower Bed	Timms Point	Saugus Wells	U. Pico Wells	L. Pico Wells	Puente
Acervulina inhaerens Schultze	.....	.....	RR	.....	.....	.....	.....	.....
Astacolus californicus, n. sp.	X	.....	.....	RR	.....	.....	.....	.....
A. planulatus, n. sp	.....	X	.....	.....	.....	.....	.....	.....
Bolivina lomitensis, n. sp.	.....	RR	.....	.....	.....	.....	.....	.....
B. modesta, n. sp.	.....	RR	.....	.....	.....	.....	.....	.....
B. sinuata, n. sp.	R	RR	RR	X	X	RR	C	A
B. spissa Cushman	RR	RR	RR	RR	C	AA	.....	.....
B. interjuncta Cushman	R	R	A	X	R	C	X	.....
Bulimina marginata d'Orbigny	RR	RR	RR	.....	C	.....	.....	.....
Carinina carinata, n. gen., n. sp.	.....	.....	RR	.....	.....	.....	.....	.....
Cassidulina californica Cushman and Hughes.	C	R	RR	AA	AA	C	R	.....
C. limbata Cushman and Hughes	R	R	C	AA	A	X	.....	.....
C. lomitensis, n. sp.	R	R	A	RR	R	RR	RC	.....
C. lomitensis var. *elegantula*, n. var	R	R	R	.....	.....	.....	.....	.....
C. quadrata Cushman and Hughes	C	C	A	.....	C	R	R	.....
C. reflexa, n. sp.	R	R	R	C	C	.....	.....	.....
C. translucens Cushman and Hughes	R	C	A	RR	R	AA	AA	.....
Cibicides conoideus, n. sp.	R	C	R	R	.....	.....	.....	.....
C. fletcheri, n. sp.	C	C	C	R	R	.....	.....	.....
C. lobatus d'Orbigny	RR	R	R	C	.....	.....	.....	.....
C. mckannai, n. sp.	R	R	R	RR	R	A	AA	.....
C. tenuimargo (Brady)	.....	.....	X	.....	.....	.....	.....	.....
Dentalina baggi, n. sp.	C	C	C	C	.....	.....	.....	.....
D. decepta (Bagg)	.....	R	.....	R	.....	.....	.....	.....
Epistomina bradyi, n. sp	R	R	R	R	RR	RR	A	.....
E. flinti, n. sp	.....	.....	R	.....	.....	.....	.....	.....
Fissurina obscurocostata, n. sp	.....	X	.....	.....	X	.....	.....	.....
F. romettensis Seguenza	.....	X	.....	X	X	X	.....	.....
Frondicularia advena Cushman	R	.....	.....	.....	.....	C	R	C
Gaudryina arenaria, n. sp	.....	R	RC	X	R	.....	.....	.....
G. grammostomata, n. sp	.....	.....	R	.....	X	.....	.....	.....
Globigerina apertura Cushman	A	A	A	X	R	R	R	.....
G. bulloides d'Orbigny	AA	AA	AA	R	A	A	A	A
G. concinna Reuss	A	A	A	R	R	R	R	.....
G. crassaformis, n. sp.	.....	R	.....	.....	RC	R	.....	.....
G. cyclostoma, n. sp.	R	R	R	.....	X	X	X	.....
G. dehiscens (Parker and Jones)	.....	.....	X	.....	X	.....	.....	.....
G. helicina d'Orbigny	RR	RR	RR	.....	.....	.....	.....	.....
G. inflata d'Orbigny	C	R	R	.....	R	C	.....	.....
G. pachyderma (Ehrenberg)	AA	AA	AA	R	A	A	.....	.....
G. quadrilatera, n. sp	C	C	C	RR	R	R	C	C
G. subcretacea Chapman	A	A	A	.....	R	R	.....	.....
Globobulimina pacifica Cushman	.....	.....	RR	RR	R	R	C	A
Globorotalia campanulata, n. sp	R	R	R	RR	.....	.....	.....	.....
G. grandis, n. sp	RR	RR	RR	C	C	.....	.....	.....
G. mccollomi, n. sp	R	R	R	RR	RR	.....	.....	.....
Hemicristellaria grandis, n. sp	.....	.....	X	.....	.....	.....	.....	.....

TABLE II—*Continued*

	Pleistocene			Pliocene				Miocene
	Lower San Pedro			Fernando				
	D. M. S. & B. Quarry			Saugus		Pico		
	Upper Bed	Middle Bed	Lower Bed	Timms Point	Saugus Wells	U. Pico Wells	L. Pico Wells	Puente
Nonion scapha (Fichtel and Moll)	C	R	RR	RR	C			
Oolina laevigata d'Orbigny			R	RR				
Orbulina universa d'Orbigny	RR	RR	RR	R	R	C	R	
Planulina ariminensis d'Orbigny	C	C	C	C	X	X		
Polymorphina (Guttulina) austrica d'Orb.	R	R	R	RR				
P. biserialis, n. sp.	R	R	R	R				
P. (Guttulina) costatula, n. sp.			R					
P. doanei, n. sp.	R	R	R	R				
P. elongata, n. sp.	R	R	R	C				
P. frondiculariformis, n. sp.			X	C				
P. obscurocostata, n. sp.		X						
P. subelliptica, n. sp.		R						
P. torta, n. sp.	R	X	C	X				
Quinqueloculina akneriana d'Orbigny	R	R	R	A	A			
Robulus cushmani, n. sp.	C	C	C	R	X	X	R	R
Rosalina hitchcockae, n. sp.			R					
R. isabelleana d'Orbigny			X					
Rotalia subtenera, n. sp.	R	R			A	RR	RR	
Rupertia stabilis Wallich			R					
Sigmoilina elliptica, n. sp.			R	X	R		R	
Spirillina vivipara Ehrenberg	X							
Themeon crispus (Linné)	A	A	A	R				
T. decipiens, n. sp.	R	R	R	RC				
Uvigerina auberiana d'Orbigny		RR		RR	RR	RR		
U. baggi, n. sp.	RR	RR	RR	RR	R			
U. farinosa Hantken			RR	RR	RR			
U. hughesi, n. sp.	RR	RR	RR	RR	RR			
U. peregrina Cushman	R	R	R	RR	R	AA	R	
U. peregrina var. *parvula* Cushman	R	R	R	X	R	A	R	
U. semitrigona, n. sp.	R	R	R	R	R			
Vaginulina robusta, n. sp.	RR							

EXPLANATION OF PLATES

Plate 7

Fig. 1. —*Spirillina vivipara* Ehrenberg, × 22.

2 *a*. —*Sigmoilina elliptica*, n. sp., × 81. *a*, apertural view; *b*, side view.

3 *a–c*.—*Quinqueloculina akneriana* d'Orbigny, × 71. *a*, *b*, side views; *c*, apertural view.

4 *a–c*.—*Globigerina bulloides* d'Orbigny, × 130. *a*, ventral view; *b*, edge view; *c*, dorsal view.

5 *a–c*.—*Globigerina apertura* Cushman, × 55. *a*, ventral view; *b*, edge view; *c*, dorsal view.

6. —*Globigerina dehiscens* (Parker and Jones), × 42.

7 *a–c*.—*Globigerina concinna* Reuss, × 100. *a*, ventral view; *b*, dorsal view; *c*, edge view.

8 *a–c*.—*Globigerina cyclostoma*, n. sp., × 55. Holotype. *a*, ventral view; *b*, edge view; *c*, dorsal view.

9 *a–c*.—*Globigerina cyclostoma*, n. sp., × 55. Paratype. *a*, ventral view; *b*, dorsal view; *c*, edge view.

10 *a, b.*—*Globigerina helicina* d'Orbigny, × 89. *a*, dorsal view; *b*, side view.
11 *a–c.*—*Globigerina quadrilatera*, n. sp., × 63. *a*, ventral view; *b*, dorsal view; *c*, edge view.
12 *a–c.*—*Globigerina crassaformis*, n. sp., × 50. *a*, ventral view; *b*, edge view; *c*, dorsal view.
13 *a–c.*—*Globigerina pachyderma* (Ehrenberg), × 61. *a*, ventral view; *b*, edge view; *c*, dorsal view.

PLATE 8

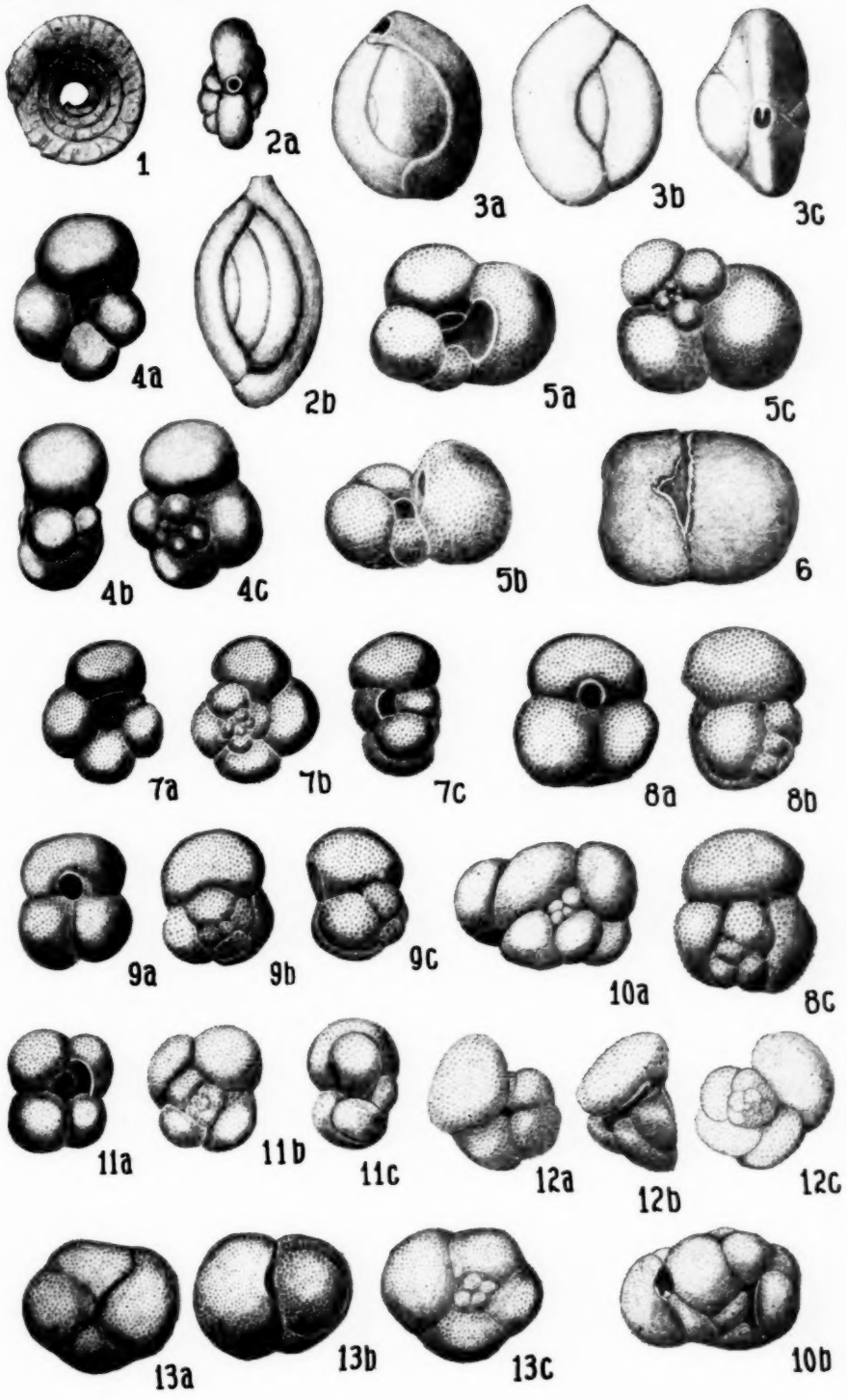
FIG. 1 *a–c.*—*Globigerina inflata* d'Orbigny, × 125. *a*, ventral view; *b*, edge view; *c*, dorsal view.
2 *a–c.*—*Globigerina subcretacea* Chapman; × 100. *a*, ventral view; *b*, edge view; *c*, dorsal view.
3. —*Orbulina universa* d'Orbigny, × 52.
4 *a, b.*—*Astacolus californicus*, n. sp., × 42. *a*, side view; *b*, edge view.
5 *a–c.*—*Astacolus planulatus*, n. sp., × 45. *a*, side view; *b*, edge view; *c*, apertural view.
6 *a, b.*—*Hemicristellaria grandis*, n. sp., × 10. *a*, side view; *b*, apertural view.
7 *a, b.*, 8—*Frondicularia advena* Cushman, × 20. 7 *a*, side view, imperfect specimen; 7 *b*, top view; 8, young specimen.
9. —*Vaginulina robusta*, n. sp., × 10.
10. —*Oolina laevigata* d'Orbigny, × 48.
11 *a, b.*—*Robulus cushmani*, n. sp., × 13. *a*, side view; *b*, edge view.
12, 13 *a, b.*—*Dentalina decepta* (Bagg), × 11. 12, 13 *a*, side views; 13 *b*, apertural view.
14, 15.—*Dentalina baggi*, n. sp., × 10. Holotype, fig. 14.

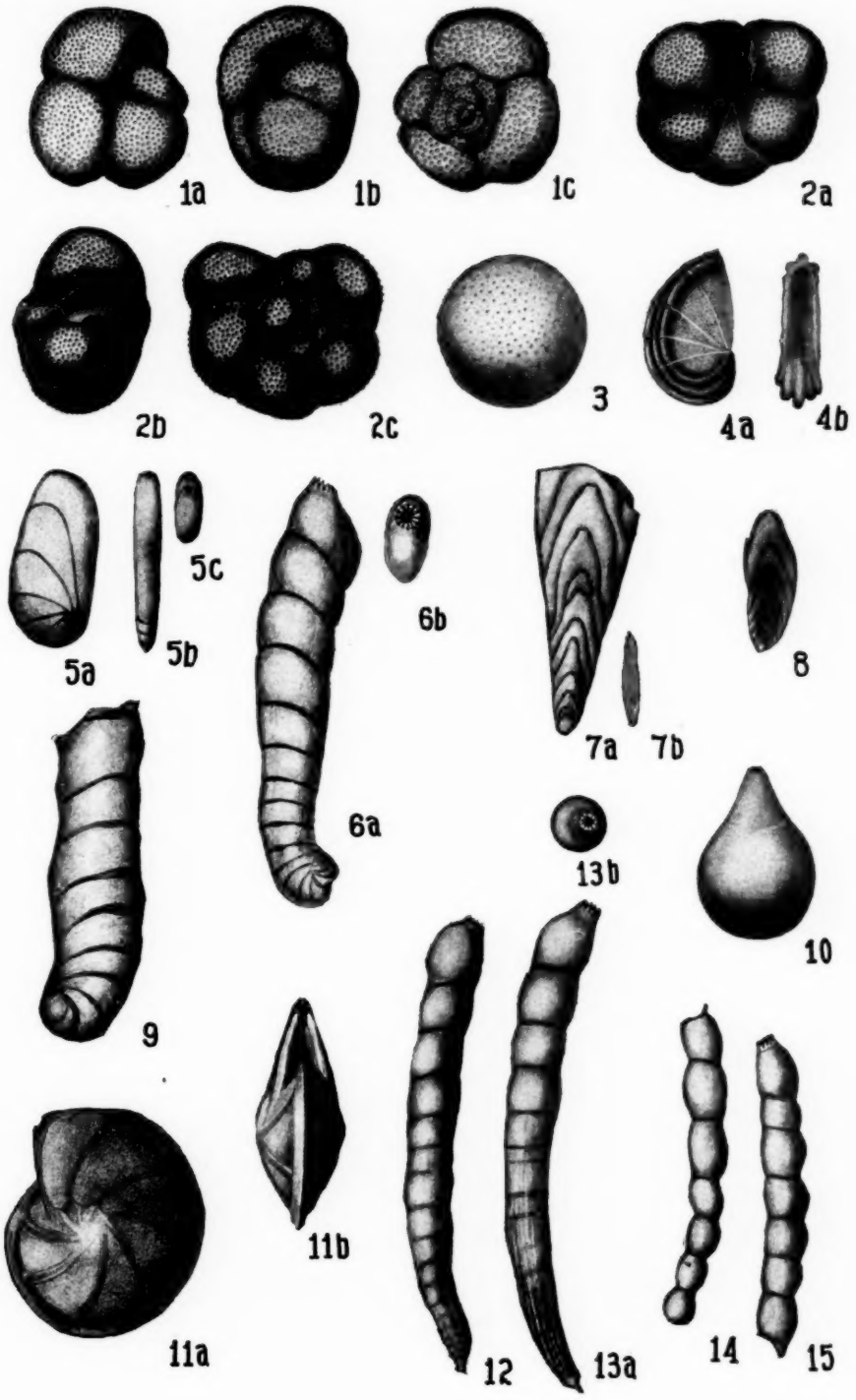
PLATE 9

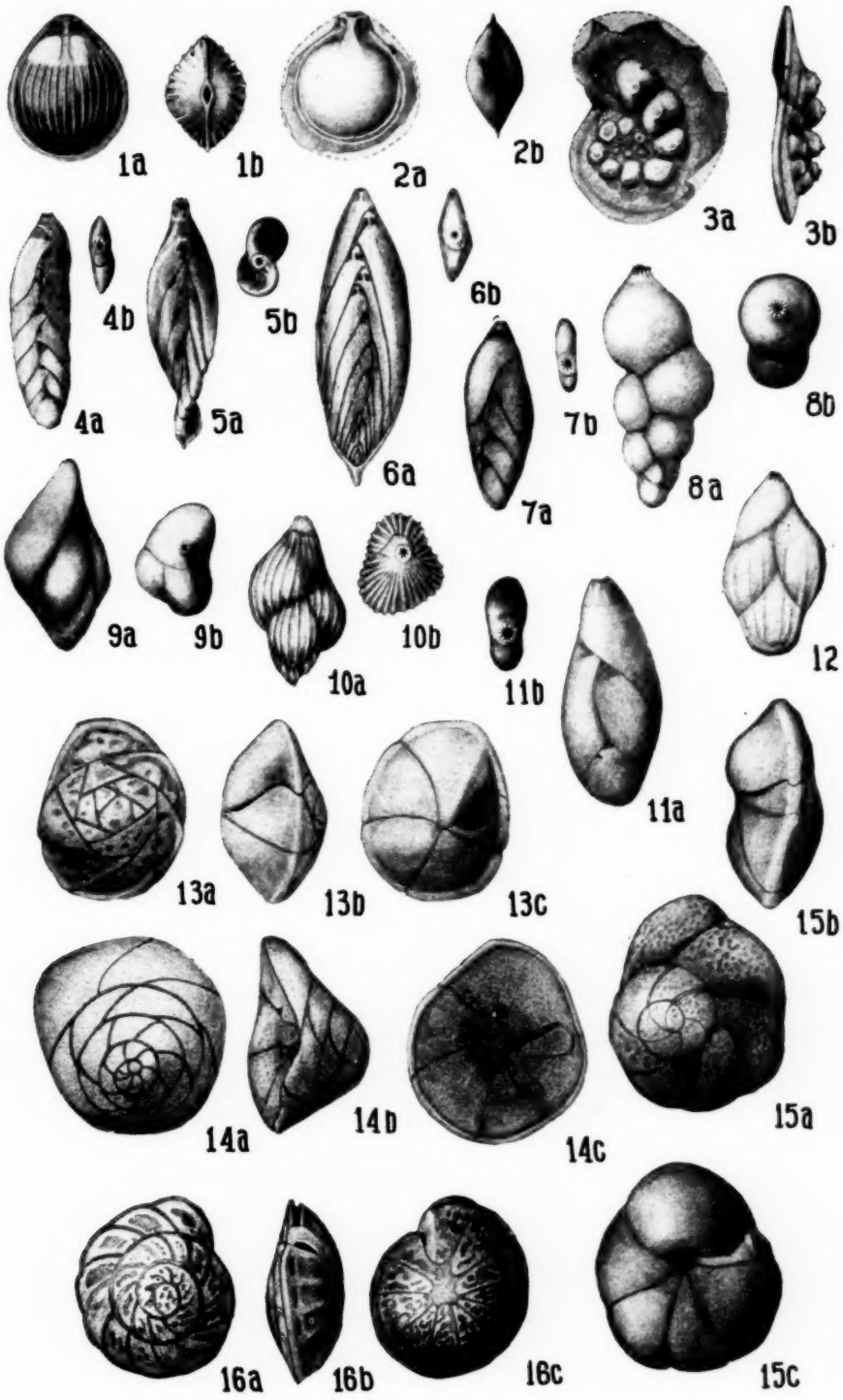
FIG. 1 *a, b.*—*Fissurina obscurocostata*, n. sp., × 87. *a*, side view; *b*, apertural view.
2 *a, b.*—*Fissurina romettensis* Seguenza, × 51. *a*, side view; *b*, apertural view.
3 *a, b.*—*Carinina carinata*, n. gen., n. sp., × 37. *a*, dorsal view; *b*, edge view.
4 *a, b.*—*Polymorphina biserialis*, n. sp., × 11. *a*, side view; *b*, apertural view.
5 *a, b.*—*Polymorphina torta*, n. sp., × 20. *a*, side view; *b*, apertural view.
6 *a, b.*—*Polymorphina frondicullariformis*, n. sp., × 20. *a*, side view; *b*, apertural view.
7 *a, b.*—*Polymorphina elongata*, n. sp., × 10. *a*, side view; *b*, apertural view.
8 *a, b.*—*Polymorphina doanei*, n. sp., × 22. *a*, side view; *b*, apertural view.
9 *a, b.*—*Polymorphina* (*Guttulina*) *austriaca* d'Orbigny, × 110. *a*, side view; *b*, apertural view.
10 *a, b.*—*Polymorphina* (*Guttulina*) *costatula*, n. sp., × 40. *a*, side view; *b*, apertural view.
11 *a, b.*—*Polymorphina subelliptica*, n. sp., × 22. *a*, side view; *b*, apertural view.
12. —*Polymorphina obscurocostata*, n. sp., × 113.
13 *a–c.*—*Globorotalia mccollomi*, n. sp., × 41. *a*, dorsal view; *b*, edge view; *c*, ventral view.
14 *a–c.*—*Globorotalia campanulata*, n. sp., × 119. *a*, dorsal view; *b*, edge view; *c*, ventral view.
15 *a–c.*—*Globorotalia grandis*, n. sp., × 20. *a*, dorsal view; *b*, edge view; *c*, ventral view.
16 *a–c.*—*Epistomina flinti*, n. sp., × 11. *a*, dorsal view; *b*, edge view; *c*, ventral view.

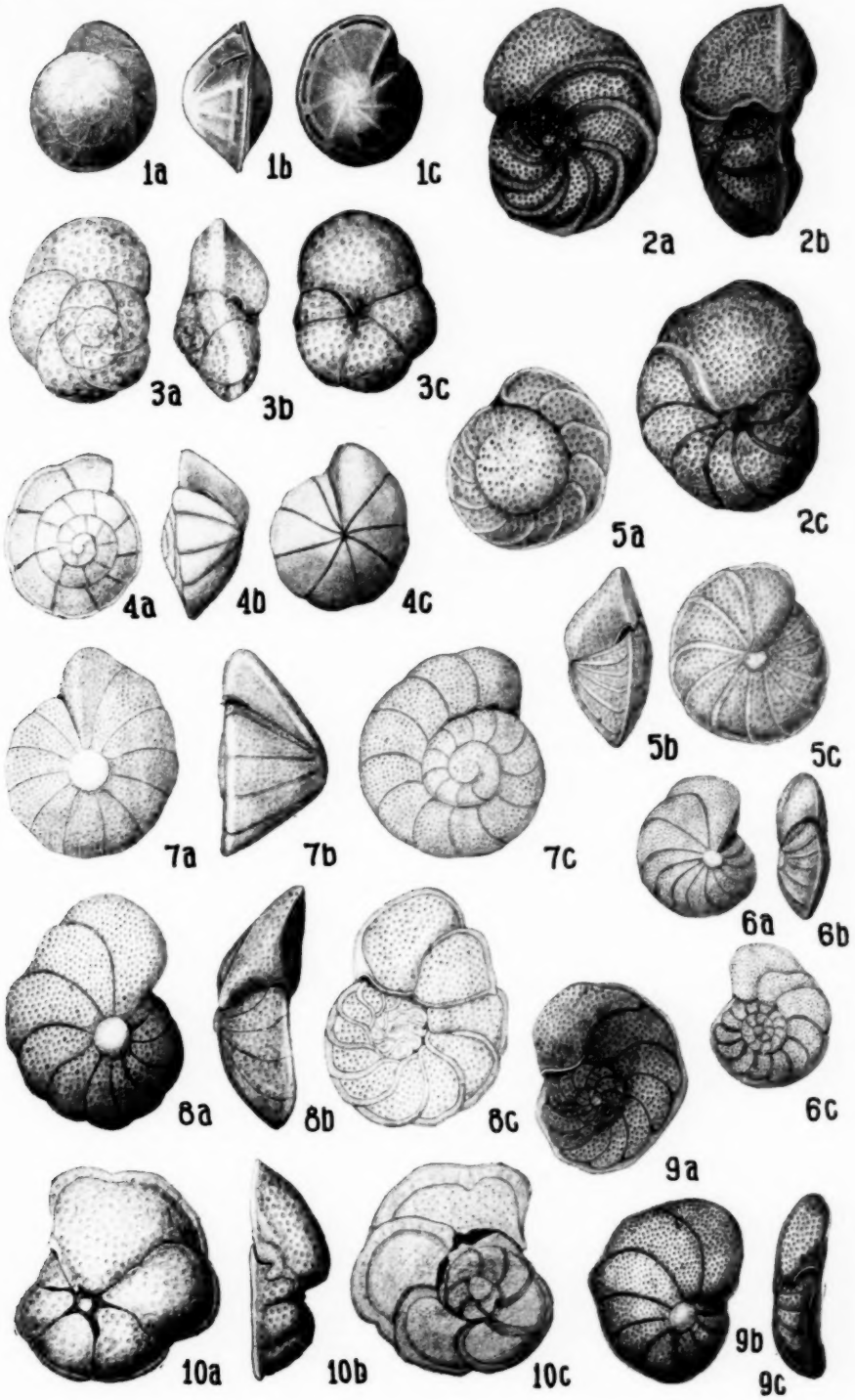
PLATE 10

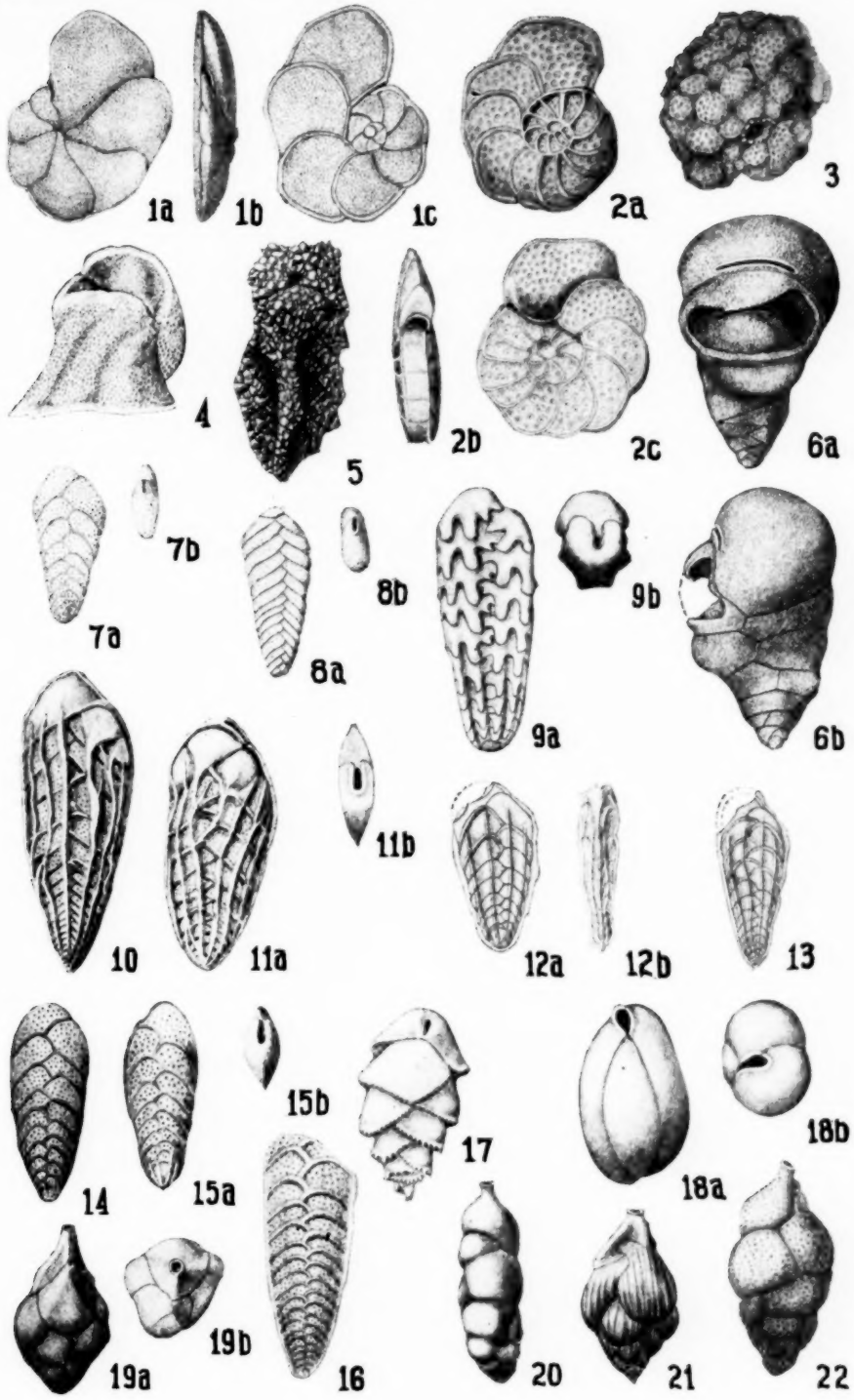
FIG. 1 *a–c.*—*Epistomina bradyi*, n. sp., × 84. *a*, dorsal view; *b*, edge view; *c*, ventral view.
2 *a–c.*—*Rosalina hitchcockae*, n. sp., × 39. *a*, dorsal view; *b*, edge view; *c*, ventral view.
3 *a–c.*—*Rosalina isabelleana* d'Orbigny, × 83. *a*, dorsal view; *b*, edge view; *c*, ventral view.
4 *a–c.*—*Rotalia subtenera*, n. sp., × 64. *a*, dorsal view; *b*, edge view; *c*, ventral view.
5 *a–c.*—*Cibicides mckannai*, n. sp., × 50. Holotype. *a*, dorsal view; *b*, edge view; *c*, ventral view.
6 *a–c.*—*Cibicides mckannai*, n. sp., × 47. Young specimen. *a*, dorsal view; *b*, edge view; *c*, ventral view.
7 *a–c.*—*Cibicides conoideus*, n. sp., × 60. *a*, ventral view; *b*, edge view; *c*, dorsal view.

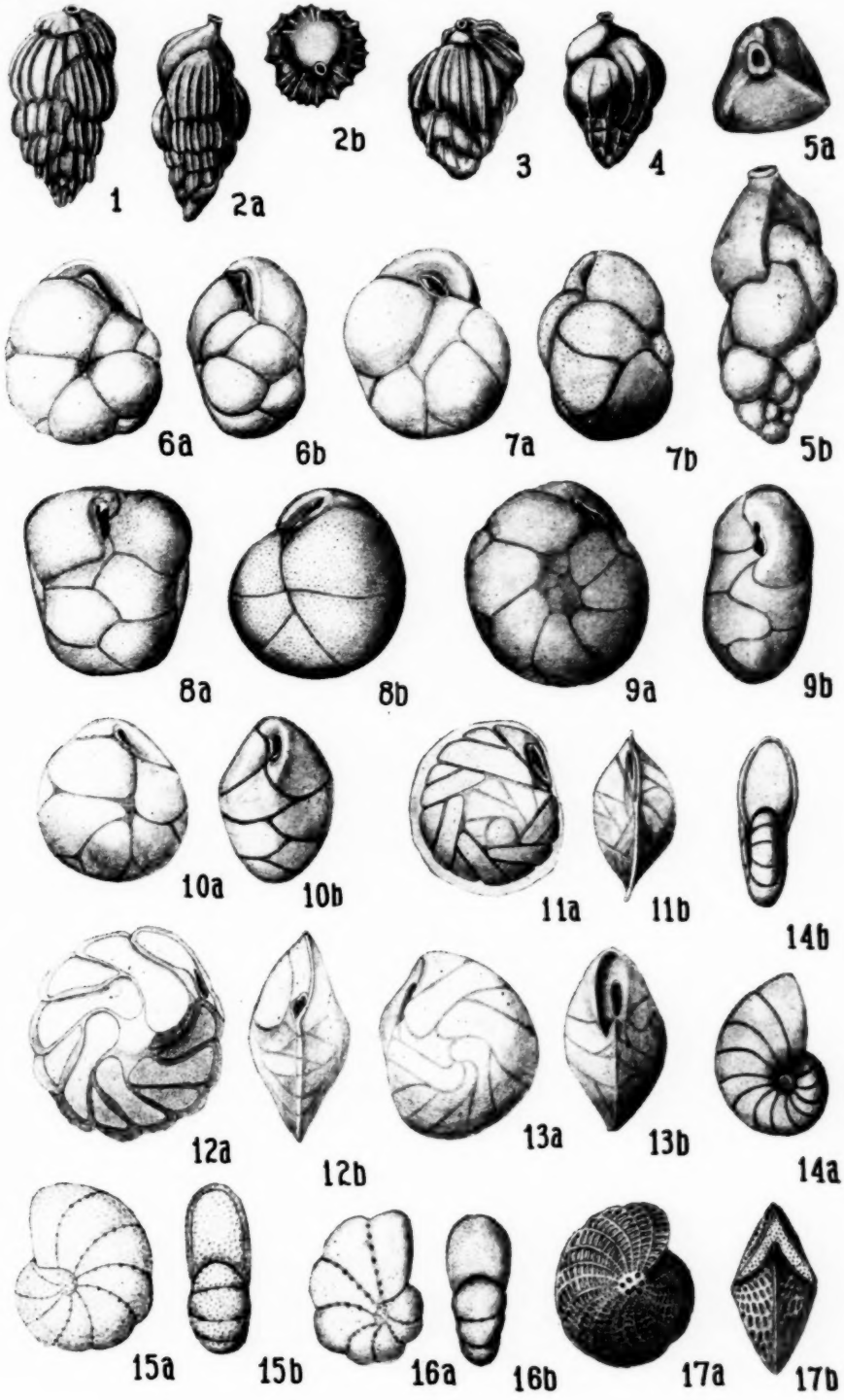

1
2a
3a
3b
3c
4a
2b
5a
5c
4b
4c
5b
6
7a
7b
7c
8a
8b
9a
9b
9c
10a
8c
11a
11b
11c
12a
12b
12c
13a
13b
13c
10b


1a
1b
1c
2a
2b
2c
3
4a
4b
5a
5b
5c
6a
6b
7a
7b
8
9
10
11a
11b
12
13a
13b
14
15


1a
1b
2a
2b
3a
3b
4b
5b
6b
4a
5a
6a
7b
8b
7a
8a
9a
9b
10a
10b
11b
12
11a
13a
13b
13c
15b
14a
14b
14c
15a
16a
16b
16c
15c


1a
1b
1c
2a
2b
3a
3b
3c
2c
5a
4a
4b
4c
5b
5c
7a
7b
7c
6a
6b
8a
8b
8c
6c
9a
10a
10b
10c
9b
9c


1a
1b
1c
2a
3
4
5
2b
2c
6a
7b
7a
8b
8a
9b
9a
6b
10
11a
11b
12a
12b
13
14
15a
15b
17
18a
18b
19a
19b
16
20
21
22


1
2a
2b
3
4
5a
5b
6a
6b
7a
7b
8a
8b
9a
9b
10a
10b
11a
11b
14b
12a
12b
13a
13b
14a
15a
15b
16a
16b
17a
17b

8 *a–c.*—*Cibicides fletcheri*, n. sp., × 50. Holotype. *a*, ventral view; *b*, edge view; *c*, dorsal view.

9 *a–c.*—*Cibicides fletcheri*, n. sp., × 51. Somewhat distorted specimen. *a*, dorsal view; *b*, ventral view; *c*, edge view.

10 *a–c.*—*Cibicides tenuimargo* (Brady), × 41. *a*, ventral view; *b*, edge view; *c*, dorsal view.

PLATE 11

FIG. 1 *a–c.*—*Cibicides lobatus* (d'Orbigny), × 47. *a*, ventral view; *b*, edge view; *c*, dorsal view.

2 *a–c.*—*Planulina ariminensis* d'Orbigny, × 60. *a*, ventral view; *b*, edge view; *c*, dorsal view.

3. —*Acervulina inhaerens* Schultze, × 27.

4. —*Rupertia stabilis* Wallich, × 30.

5. —*Gaudryina arenaria*, n. sp., × 40.

6 *a, b.*—*Gaudryina grammostomata*, n. sp., × 35. *a*, edge view; *b*, side view.

7 *a, b.*—*Bolivina lomitensis*, n. sp., × 40. *a*, side view; *b*, apertural view.

8 *a, b.*—*Bolivina modesta*, n. sp., × 50. *a*, side view; *b*, apertural view.

9 *a, b.*—*Bolivina sinuata*, n. sp., × 41. *a*, side view; *b*, apertural view.

10, 11 *a, b.*—*Bolivina interjuncta* Cushman, × 40. 10, microspheric: 11, megaspheric; *a*, side view; *b*, apertural view.

12 *a, b*, 13.—*Bolivina interjuncta* Cushman. Young specimens. 12, megaspheric × 40; *a*, side view; *b*, edge view: 13, microspheric × 30.

14–16. —*Bolivina spissa Cushman.* 14, 15, megaspheric × 50; 15, *a*, side view; *b*, apertural view: 16, microspheric × 46.

17. —*Bulimina marginata* d'Orbigny, × 60.

18 *a, b.*—*Globobulimina pacifica* Cushman, × 41. *a*, side view; *b*, apertural view.

19 *a, b.*—*Uvigerina baggi*, n. sp., × 50. *a*, side view; *b*, apertural view.

20. —*Uvigerina farinosa* Hantken, × 82.

21. —*Uvigerina semitrigona*, n. sp., × 52.

22. —*Uvigerina auberiana* d'Orbigny, × 50.

PLATE 12

FIG. 1, 2 *a, b.*—*Uvigerina peregrina* Cushman. 1, adult specimen × 36: 2, submature specimen × 43; *a*, side view; *b*, apertural view.

3, 4.—*Uvigerina peregrina parvula* Cushman. 3, × 36; 4, × 35.

5 *a, b.*—*Uvigerina hughesi*, n. sp., × 78. *a*, apertural view; *b*, side view.

6 *a, b*, 7 *a, b.*—*Cassidulina californica* Cushman and Hughes. 6, typical adult specimen × 25; *a*, side view; *b*, edge view: 7, young specimen ×37; *a*, side view; *b*, edge view.

8 *a, b.*—*Cassidulina quadrata* Cushman and Hughes, × 35. *a*, edge view; *b*, side view.

9 *a, b.*—*Cassidulina lomitensis elegantula*, n. sp., n. var., × 21. *a*, side view; *b*, edge view.

10 *a, b.*—*Cassidulina lomitensis*, n. sp., × 32. *a*, side view; *b*, edge view.

11 *a, b.*—*Cassidulina translucens* Cushman and Hughes, × 52. *a*, side view; *b*, edge view.

12 *a, b.*—*Cassidulina limbata* Cushman and Hughes, × 50. *a*, side view; *b*, edge view.

13 *a, b.*—*Cassidulina reflexa*, n. sp., × 80. *a*, side view; *b*, edge view.

14 *a, b.*—*Nonion scapha* (Fichtel and Moll), × 35. *a*, side view; *b*, edge view.

15 *a, b.*—*Themeon granulosa*, n. sp., × 100. Holotype. *a*, side view; *b*, edge view.

16 *a, b.*—*Themeon granulosa*, n. sp., × 100. Paratype. A more lobulated specimen. *a*, side view; *b*, edge view.

17 *a, b.*—*Themeon crispus* (Linné), × 30. *a*, side view; *b*, edge view.

FOSSIL ZONES OF THE EAGLE FORD OF NORTH TEXAS[1]

W. L. MOREMAN
Texas Christian University, Fort Worth, Texas

ABSTRACT

The Eagle Ford includes a great variety of both large and microscopic fossils. It is possible to divide the formation into definite zones based mainly on the ammonites as follows, from the bottom upward: zones of *Acanthoceras rotomagense, Metoicoceras irwini, Metoicoceras whitei, Metoicoceras swallovi, Helicoceras pariense, Metoicoceras gibbosum, Gauthiericeras bravaisi, Prionotropis woolgari,* and zone of transition beds at the Eagle Ford–Austin chalk contact. Two of these horizons are present in the lower half of the formation, while the others are in the upper half. The microscopic fossils, especially the Foraminifera, have been checked at various levels. The transition between the Eagle Ford and Austin chalk can be traced from Sherman to Austin.

INTRODUCTION

This formation was first named by Hill from Eagle Ford, a village west of Dallas, where it is typically exposed. It corresponds to the Benton of the Meek and Hayden section in the west central states and has been correlated with the Turonian of the European section.

Many descriptions of the Eagle Ford may be found in the literature of this region, but its general lithological and paleontological characteristics are best described by Hill, and his observations furnish a basis for all future study.[2] The most recent work is that by Scott, who established three fossil zones in the Eagle Ford. It is the purpose of this preliminary paper to indicate a number of additional zones; to present a more detailed study of the paleontology with relation to the fossil zones, particularly those formed by ammonites; to discuss their stratigraphic importance; and also to establish the relationship of occurrence of the microscopic and the larger fossils. The writer intends later to describe the fauna of the Eagle Ford in detail.

In the accomplishment of this piece of research the writer wishes to make grateful acknowledgment for the assistance given him by Professor W. M. Winton, head of the department of geology at Texas Christian University, for his suggestions and aid both in the field and with the photographic work; to Dr. Gayle Scott, professor of geology at Texas Christian University, for his suggestions and identification of some of the ammonites; to Helen Jeanne Plummer for invaluable aid in

[1] North Texas indicates the area lying between Waco and Denison.

[2] R. T. Hill, "Black and Grand Prairies of Texas," *Twenty First Annual Rept. of U. S. G. S.* (1901); B. F. Shumard, "Observations upon the Cretaceous Strata of Texas," *Trans. of the Acad. of Sci. of St. Louis,* 1860; J. A. Taff, "Report of the Cretaceous Area North of the Colorado River," *Fourth Annual Rept. Geol. Survey of Texas* (1892); L. W. Stephenson, "A Contribution to the Geology of Northeastern Texas and Southern Oklahoma," *U. S. G. S. Prof. Paper No. 120* (1918); W. M. Winton and W. S. Adkins, "The Geology of Tarrant County," *Univ. of Texas Bull. No. 1931* (1919); Gayle Scott, *Etudes stratigraphiques et paleontologiques sur les terrains cretaces du Texas* (These Doctorat, Grenoble, 1925); Gayle Scott, "The Woodbine Sand of Texas Interpreted as a Regressive Phenomenon," *Bull. of the Amer. Assoc. of Pet. Geol.,* vol. 10, No. 6 (1926).

the identification and selection of the microscopic fossils; and to C. I. Alexander for identification of the Ostracoda.

LITHOLOGY AND PALEONTOLOGY

The Eagle Ford is very extensive in Texas, forming an outcrop across the entire state, from the Red River to the Rio Grande River. The thickness varies at different localities, reaching a maximum of from 500 to 600 feet in North Texas, between Dallas and Sherman; while at Austin it is only about 30 feet thick. West of Austin the thickness increases and is some 200 or 300 feet in the Rio Grande region. Hill states that the decrease in thickness southward from the Red River is probably due to a gradual disappearance in that direction of the lower beds, until at Austin only the upper part of the formation is represented. Observations of the writer and others tend to confirm this. The dip is 29 to 52 feet per mile.

The lithologic characters of the Eagle Ford are unlike at different levels, but the formation consists mainly of bituminous shales. In North Texas between Dallas and Tarrant Station, and between Britton and Midlothian, nearly the entire formation can be studied. A generalized section would be about as follows: Woodbine sand above which the Eagle Ford begins as a conglomeratic layer, next about 150 feet of typical blue to gray shale with occasional flaggy arenaceous and calcareous layers. Above this for 50 feet or more the shale contains a high percentage of calcareous material which gives it almost a white color. These beds are continuous for some distance and might be considered to locally represent a definite zone based on the lithology. The remaining 300 feet include the typical blue shale which becomes finely laminated toward the top. In places these beds are almost micaceous in texture and contain fossils preserved as casts with a thin film of the original nacre. At intervals there are flaggy layers, and at two levels 75 and 100 feet below the top these layers form beds which sometimes make distinct escarpments. Throughout the formation are septaria which become larger and more abundant in the upper layers. The upper member includes many large, rounded concretions some of which exhibit fantastic shapes.

Such minerals as gypsum, calcite, pyrite, glauconite, phosphate nodules, quartz, etc., may be found in the shale. Gypsum is especially abundant, filling cracks and crevices and sometimes forming large crystals.[1]

The Eagle Ford shales are important as a source of petroleum. The fields of the Mexia district have produced a great quantity of oil from the Woodbine sands. There seems little doubt that the origin of this was in the Eagle Ford shales.

In the past it has been considered impossible to establish definite fossil zones in the Eagle Ford because the exposures are so few and widely separated. Nevertheless there are a few localities where the succession of the beds can be determined, for example, between Dallas and Tarrant Station along the St. Louis, San Francisco and Texas Railroad; between Midlothian and Britton along the Houston and

[1] For more detailed study of the lithological characters the reader is referred to R. T. Hill, "The Black and Grand Prairies of Texas," *op. cit.*, pp. 323–28.

Texas Central Railroad, and between Lewisville and Hebron in Denton County. Where exposures do occur, fossils are usually abundant and the formation seems to yield itself readily to zoning.

As stated above, three zones have already been established by Scott, one at the base which is that of *Acanthoceras* aff. *rotomagense* (de France), another about the middle represented by *Metoicoceras whitei* Hyatt, and the zone of *Prionotropis woolgari* Mantell near the top. In addition to these, the writer has been able to determine several others, represented mainly by ammonites. The horizons which have been located up to the present time are as follows:

Zone of *Eagle Ford–Austin chalk transition*
Zone of *Prionotropis* aff. *woolgari*
Zone of *Gauthiericeras* aff. *bravaisi*
Zone of *Metoicoceras gibbosum*
Zone of *Helicoceras pariense*
Zone of *Metoicoceras swallovi*
Zone of *Metoicoceras whitei*
Zone of *Metoicoceras irwini*
Zone of *Acanthoceras* aff. *rotomagense*

Paleontologically, the Eagle Ford is often considered dull; but at certain levels, notably in the upper beds, fossils are very abundant. Fish remains, such as teeth, vertebrae, and scales, may be found at almost any level. The teeth vary in size from large shark teeth to those of microscopic size. The most common bony fish which lived during this time was *Holcolepis pulchellus* Cockrell. Scales of this species are common and sometimes an entire cast may be preserved.

Inocerami are abundant throughout the formation and include *Inoceramus labiatus* Schlotheim, *Inoceramus fragilis* Hall and Meek, *Inoceramus capulus* Shumard, etc.

At the base of the Eagle Ford at its contact with the Woodbine there is a conglomeratic layer containing numerous fossils many of which are unrecognizable. The most common ones are *Exogyra columbella* Meek, *Engonoceras planum* Hyatt, and *Acanthoceras* aff. *rotomagense* (de France) (plate 13, fig. 1). The microscopic fossils include Foraminifera, Ostracoda, fish remains, and crustacean fragments.

Above this the light-gray to white beds contain numerous Inocerami and fish scales. A concentrated sample of this material consists almost entirely of *Inoceramus* prisms and several species of *Globigerina*.

At a level about 200 feet from the base of the formation are a number of fossils as *Metoicoceras irwini*, n. sp. (plate 13, figs. 3, 4), *Placenticeras* sp., *Pachydiscus* sp. A (plate 5, fig. 4), *Hemitissotia* sp. A (plate 14, fig. 1) and *Inoceramus labiatus* Schlotheim. The concentrated material contains a large variety of Foraminifera, Ostracoda, and other organic remains.

In the middle and upper part of the Eagle Ford the fossils are more numerous and varied as to species. The most common types are *Inoceramus labiatus* Schlo-

theim, *Prionotropis* aff. *woolgari* (Mantell) (plate 13, fig. 2), *Placenticeras pseudoplacenta* var. *occidentale* Hyatt, *Placenticeras pseudoplacenta* Hyatt, *Metoicoceras whitei* Hyatt (plate 15, fig. 1), *Metoicoceras swallovi* (Shumard) (plate 15, fig. 3), *Helicoceras pariense* White (plate 14, fig. 3), *Acanthoceras* sp. A (plate 15, fig. 2), *Gautheiriceras* aff. *bravaisi* (d'Orbigny) (plate 14, fig. 2), *Baculites gracilis* Shumard, numerous small clams, gastropods, fish remains, Foraminifera, and Ostracoda.

At the Eagle Ford–Austin chalk contact is a transition zone of considerable extent which has a rich microscopic fauna including Ostracoda, crustacean fragments, fish remains, and several genera of Foraminifera. A few large fossils are present as fish teeth, *Ostrea lugubris* Conrad, and other small clams.

Zone of *Acanthoceras* aff. *rotomagense*

Acanthoceras aff. *rotomagense* (de France) (plate 13, fig. 1) represents the first zone in the Eagle Ford. This fossil is abundant in the lower part of the formation $2\frac{1}{2}$ miles east of Tarrant near the St. Louis, San Francisco and Texas Railroad. It has been listed and described by a number of writers from the upper Cenomanian of Europe and other countries; but very few, if any, specimens have been found in north Texas except at this locality and one or two others only a short distance from it.

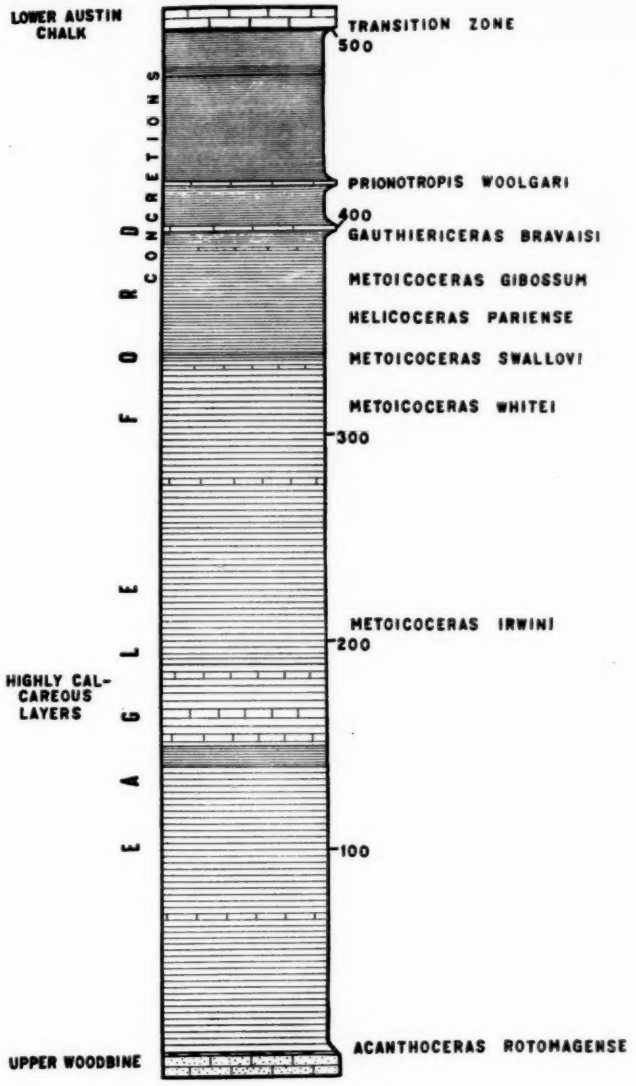
Associated with *Acanthoceras* aff. *rotomagense* are *Engonoceras planum* Hyatt, *Exogyra columbella* Meek, *Ostrea soleniscus* Meek, *Gyrodes* sp., numerous fish teeth, and other fragmentary fossils. The conglomeratic layer at this zone is made up of fish teeth, fragmentary shells of various kinds, with a great amount of phosphate nodules and large concretions.

The microscopic fossils are few, but sometimes *Globigerina dubia* Egger, *Globigerina cretacea* d'Orbigny (plate 16, figs. 14, 15), *Guembelina globulosa* (Ehrenberg) (plate 16, fig. 10), *Anomalina* sp., and Ostracoda are present. The concentrate consists mostly of sand grains and other inorganic particles.

Zone of *Metoicoceras irwini*

Metoicoceras irwini, n. sp. (plate 13, figs. 3, 4), the ammonite upon which this zone is based, was first found by the writer about 6 miles northwest of Irving at an exposure near the Irving Coppell Road. It represents a zone considerably below the middle of the Eagle Ford; probably at a level about 150 to 200 feet above the zone of *Acanthoceras* aff. *rotomagense*.

This species of *Metoicoceras* is much more compressed than the other members of the group, being about the same thickness near the umbilicus as it is at the ventral margin. The umbilicus is broader than in *Metoicoceras swallovi* and *Metoicoceras whitei*. In the specimen here figured, which is 22 cm. across, the umbilicus measures 4 cm. The two rows of tubercles along each side of the ventral-lateral margin are distinct but not so prominent as in other members of the genus. The ribs diminish toward the umbilicus so that the region of the umbilicus is relatively smooth.



GENERALIZED SECTION

FIG. 1

The lobes of the suture increase in size gradually from the umbilicus toward the ventral margin and all of the lobes are broader and not as long as in *Metoicoceras swallovi* and *Metoicoceras whitei*. The first lateral lobe is especially broad and slightly longer than the ventral lobe. The suture is more closely related to *Metoicoceras gibbosum* than to any of the others. There are of course slight variations in other specimens of this species; sometimes they are a little thicker or the ornamentation may be more distinct.

The main differences, however, between *Metoicoceras irwini* and other members of this group thus far described are that it is more compressed, the ornamentation especially around the umbilicus is less distinct or even absent, while the lobes of the suture are broader and not as long as in other forms.

The ammonite in question has been compared with figures representing members of this group from the Turonian of Western France described by de Grossouvre,[1] but the figures are not sufficient to justify reference of this form to any of his species.

It should be noted in passing that de Grossouvre considers the genus *Metoicoceras* Hyatt as identical with the genus *Mammites* Laube and Bruder. The suture of *Metoicoceras* is similar to *Mammites pervinquieri* de Grossouvre, but other characters are markedly different. The writer, however, is not prepared at present to enter into a discussion of this problem.

Two other ammonites, *Hemitissotia* sp. A (plate 14, fig. 1), and *Pachydiscus* sp. A (plate 15, fig. 4), probably new species, are associated with this zone. Only one specimen of each has been found so far, and it is possible that they will prove to represent two other zones when search has been made for more specimens.

The *Hemitissotia* sp. A is interesting because it is the only representative of this genus, so far as the writer knows, to be observed in the Western Hemisphere. The genus is, however, represented by many species and individuals in the region of North Africa and other Mediterranean districts. Fragments of a *Placenticeras* sp. have been found at this level but none sufficiently complete to be identifiable.

The microfossils are well preserved and represent a variety of forms. The Foraminifera include *Globigerina cretacea* d'Orbigny (plate 16, figs. 14, 15), *Globigerina dubia* Egger, *Guembelina globulosa* (Ehrenberg) (plate 16, fig. 10), *Gaudryina filiformis* Berthelin (plate 16, fig. 8), *Robulus cultratus* Montfort (plate 16, figs. 6, 7), *Verneuilina* sp., *Frondicularia alata* d'Orbigny, var., *Vaginulina* sp., *Anomalina eaglefordensis*, n. sp. (plate 16, figs. 9 *a*, *b*), *Anomalina* sp. The Ostracoda include *Cythereis ornatissima* (Reuss), *Bairdia subdeltoidea* (Münster) (plate 16, fig. 18), *Cytherella muensteri* (Roemer) (plate 16, fig. 13).

Zone of *Metoicoceras whitei*

Metoicoceras whitei Hyatt (plate 15, fig. 1) is one of the most abundant forms in the Eagle Ford, and the extent of the zone has been closely traced. Numerous

[1] A. de Grossouvre, "Le Cretacé de la Loire-Inferieure et de la Vendee," *Extrait du Bulletin de la Societé des Sciences Naturelles de l'ouest de la France.* 3 Ser. t. II, Nantes 1912.

specimens have been collected about 3 miles northwest of Midlothian in a small creek near the Houston and Texas Central Railroad. Also a number of other localities occur in Travis, Ellis, Dallas, Denton, and Grayson counties.

This zone is situated above the middle of the formation approximately 100 feet below the top (see generalized section, page 93, fig. 1). It is the first of a series of zones in the upper part of the formation which occur rather close together.

Associated with this species are *Placenticeras pseudoplacenta*, var. *occidentale* Hyatt, *Placenticeras pseudoplacenta* Hyatt, *Acanthoceras* sp. A (plate 15, fig. 2), *Inoceramus labiatus* Schlotheim, *Baculites gracilis* Shumard, *Lunatia* sp., *Fasciolaria*? sp. and numerous small clams.

The microfossils include *Quinqueloculina stelligera* Schlumberger (plate 16, fig. 11), *Guembelina globulosa* (Ehrenberg) (plate 16, fig. 10), *Globigerina cretacea* d'Orbigny (plate 16, figs. 14, 15), *Bairdia subdeltoidea* (Münster) (plate 16, fig. 18), *Cytherella muensteri* (Roemer) (plate 16, fig. 13), etc.

Zone of *Metoicoceras swallovi*

Metoicoceras swallovi (Shumard) (plate 15, fig. 3) occurs some 10 to 15 feet above *Metoicoceras whitei;* and at localities where 25 or 30 feet of the sediments are exposed, the two species are often found together in the stream beds. However, several localities occur where the two species may be found separately, and *Metoicoceras swallovi* is always above *Metoicoceras whitei.* It is likely that these zones may be found to overlap in some cases since they are so close together.

Acanthoceras? knabense Stanton (plate 13, fig. 5) is present in both the zone of *Metoicoceras whitei* and *Metoicoceras swallovi.* This species is well preserved and has long spines extending from the large rounded knobs on the lateral margin, as shown in figure 5. Other imprints in the shales show even longer spines than this specimen has. Stanton places this species in the genus *Acanthoceras* but states that it is unlike the typical *Acanthoceras* and should be referred to a different genus.[1]

Baculites gracilis Shumard, *Scaphites vermiformis* Meek, and Hayden, *Inoceramus labiatus,* and small clams, gastropods, and fish remains are also common.

The microfossils are very much the same as listed in the zone of *Metoicoceras whitei.*

Zone of *Helicoceras pariense*

Helicoceras pariense White (plate 14, fig. 3) makes up a zone several feet in thickness and occurs just above *Metoicoceras swallovi.* A typical locality where this species occurs is found about 3 miles northwest of Midlothian at an exposure north of the Houston and Texas Central Railroad. This form is very abundant in the shale layers and is sometimes preserved in the hard concretions. *Helicoceros pariense* is also abundant at localities in Dallas and Denton counties.

Many small clams, such as Pectens and razor clams, are abundant and preserved with the original nacre. They are very delicate and are never seen except

[1] T. W. Stanton, "The Colorado Formation and Its Invertebrate Fauna," *Bull. of the U. S. G. S. No. 106* (1893), p. 182.

when the unweathered shale is broken open. *Baculites gracilis* is again found at this level; in fact, this fossil seems to have considerable range, being found in most of the upper half of the formation.

Microfossils are about the same as listed in the zone of *Metoicoceras whitei.*

Zone of *Metoicoceras gibbosum*

Metoicoceras gibbosum Hyatt (plate 14, fig. 4) represents the uppermost species of this genus known to me. It is especially abundant in exposures west and southwest of Dallas. At these localities the lithology is that of very finley laminated shale containing much gypsum and other minerals which make preservation of fossils poor.

Fragments of *Placenticeras* sp. were found with *Metoicoceras gibbosum,* but no other forms of interest have been noted.

No microscopic fossils have been found in this material.

Zone of *Gauthiericeras* aff. *bravaisi*

Gauthiericeras aff. *bravaisi* (d'Orbigny) (plate 14, fig. 2) forms a zone which has been closely studied over a considerable area in North Texas, especially in McLennan, Hill, and Denton counties. The specimen figured was found in a locality 7 miles east of Lewisville. Other localities occur northeast of Maypearl and southwest of Waco.

Gauthiericeras bravaisi occurs in the Turonian of Europe only in a few places. It has received very little attention in American literature but is abundant in the upper Eagle Ford at the localities mentioned above. Meek[1] suggests that *Ammonites bravaisianus,* as described by d'Orbigny, resembles *Prionotropis woolgari* and that these names may have been proposed for young specimens of this species at different stages of development. Many specimens, representing different stages in the development of these two forms, have been examined by the writer, and there seems to be no doubt that the two species are distinct. *Gauthiericeras bravaisi* is characterized by the two rows of tubercles on each side of the ventral-lateral margin at all stages of its development; while the young of *Prionotropis woolgari* has ribs which are devoid of tubercles in the extremely young stage. A comparison of the figures on plates 1 and 2 will show the different characteristics. The two forms occur at different levels, another fact in favor of their distinction.

In Denton County *Gauthiericeras* aff. *bravaisi* occurs in the shale just below a number of flaggy limestone layers which comprise several feet of sediments, and occasionally imprints have been found in the hard layers. In Hill County, northeast of Maypearl, this species is found in the shale and in thin sandstone ledges.

Numerous Inocerami may be found at this zone. Bones of a large reptile were exposed at the Denton locality 7 miles east of Lewisville. Mososaurs have been found before in the Eagle Ford.

The microfossils are not very abundant at this level.

[1] F. B. Meek, "A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country," *U. S. G. S. of Territories,* 1876, p. 457.

Zone of *Prionotropis* aff. *woolgari*

Prionotropis aff. *woolgari* (Mantell) (plate 13, fig. 2), so far as the writer knows, represents the last zone of ammonites in the Eagle Ford, as no others have been cited above this level. *Prionotropos* aff. *woolgari* is present in both the shale and flaggy layers about 75 feet below the top of the formation. Exposures are quite numerous making it possible to study this zone over a considerable part of North Texas. The best exposures are in eastern Denton County where *Prionotropis* aff. *woolgari* forms a zone some 20 feet in thickness. Here it is preserved in the shale, while west of Dallas the flaggy layers contain numerous specimens. At the Dallas locality they are excellently preserved, sometimes retaining the original shell covering.

Most of the specimens are of young forms, but a few fragments of adults have been found. The adult of this species occurs in great abundance in the Benton of the west central states.

A concentrated sample of material from this zone reveals *Globigerina cretacea* d'Orbigny (plate 16, figs. 14, 15), *Guembelina globulosa* (Ehrenberg) (plate 16, fig. 10), *Anomalina eaglefordensis*, n. sp. (plate 16, figs. 9 *a*, *b*), etc.

Zone of Eagle Ford–Austin Chalk Transition

This zone has been traced and carefully studied at a number of places between Sherman and Austin. It is represented by a thickness of from a few inches to 4 or 5 feet and is usually very fossiliferous. The large fossils and lithologic samples have been gathered from exposures near Sherman, at Frisco, west of Dallas, Midlothian, northeast of Maypearl, southwest of Waco, northeast and southwest of Austin, etc. At all of these places the lithology is much the same and the association of fossils and minerals is similar.

The sediments making up this zone are blue to gray in appearance and slightly more granular than the shale below. This bed is overlain by the massive white limestone of the Austin chalk.

Large fossils found in this zone include numerous fish remains, especially teeth and vertebrae. One specimen of the bony fish *Holcolepis pulchellus* Cockrell was obtained from an exposure in Grayson County. *Ostrea lugubris* Conrad, *Tapes* sp., *Inoceramus* sp., etc., are abundant.

The concentrated material consists of black and gray granules and contains a very rich microscopic fauna. The common forms include *Globigerina cretacea* d'Orbigny (plate 16, figs. 14, 15), *Robulus cultratus* Montfort (plate 16, figs. 6, 7), *Guembelina globulosa* (Ehrenberg) (plate 16, fig. 10), *Anomalina eaglefordensis*, n. sp. (plate 16, figs. 9 *a*, *b*), *Globotruncana arca* (Cushman) (plate 16, fig. 16), *Vaginulina simondsi* Carsey (plate 16, fig. 1), *Vaginulina webbervillensis* Carsey (plate 16, fig. 2), *Frondicularia alata* d'Orbigny (plate 16, fig. 3), *Frondicularia hebronensis*, n. sp. (plate 16, fig. 4), *Nodosaria communis* d'Orbigny (plate 16, fig. 5), Ostracoda as *Cythereis ornatissima* (Reuss), *Cytherella muensteri* (Roemer) (plate 16, fig. 13),

and *Cythere cornuta* (Roemer). Crustacean fragments as the chela and fish remains are also present.

Besides the great variety of organic remains, there are a number of minerals such as jasper, garnet, calcite, gypsum, glauconite, pyrite, and phosphate nodules. One of the characteristics of this zone is the presence of a great amount of glauconite and phosphate nodules. These minerals are abundant at every locality studied and indicate that the sea at this time was shallow and in transgression.[1]

From the evidences furnished by the glauconite, phosphate nodules, and broken shell fragments there is sufficient indication to show that the sea withdrew at the end of the Eagle Ford time and returned in transgression at the beginning of the Austin halk. The gap between the two formations could not have been very long, although there is no way to determine its exact duration.

There are other phosphate ledges in the Eagle Ford near the Red River region which indicate that the sea must have had a number of short regressions and transgressions. Besides containing phosphate nodules, these ledges have a great many fish teeth imbedded in them; and one in particular, exposed in Fannin County, is called by Taff the "Fish Bed Conglomerate." The transition zone at the Eagle Ford–Austin chalk contact is often referred to by this name.

DESCRIPTION OF MICROFOSSILS

The microscopic fossils were studied principally at two levels in the Eagle Ford. One from the zone of *Metoicoceras irwini* which is situated some 150 to 200 feet from the base of the formation. The locality is 6 miles northwest of Irving near the Irving-Coppell Road where a small creek that runs toward the Elm Fork has exposed sediments with small escarpments which face the southeast.

The other level is that of the transition zone at the contact with the Eagle Ford and Austin chalk. The locality from which samples were studied is 2.2 miles north of Hebron at an exposure made by a small creek which cuts through the escarpment $\frac{1}{4}$ mile east of the St. Louis, San Francisco and Texas Railroad, and to the south of a cross-road running east and west.

The type specimens from which the species have been described will be deposited in the Museum at Texas Christian University, Fort Worth, Texas.

VAGINULINA SIMONDSI Carsey

Plate 16, fig. 1

Vaginulina simondsi Carsey, Univ. Tex. Bull. No. 2612, 1926, p. 40, pl. 2, fig. 4.

Locality, 2 miles north of Hebron.

VAGINULINA WEBBERVILLENSIS Carsey

Plate 16, fig. 2

Vaginulina webbervillensis Carsey, Univ. Tex. Bull. No. 2612, 1926, p. 39, pl. 2, fig. 7.

Locality, 2 miles north of Hebron.

[1] M. L. Cayeux, *Introduction a l'Etude Petrographique des Roches Sedimentaires*, 1916. E. D. Harder, "Iron-Depositing Bacteria and Their Geologic Relations," *U. S. G. S. Prof. Paper No. 113* (1919).

FRONDICULARIA ALATA d'Orbigny

Plate 16, fig. 3

Frondicularia alata d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 256; Carsey, Univ. Tex. Bull. No. 2612, 1926, p. 40, pl. 2, fig. 1.

Locality, 2 miles north of Hebron.

FRONDICULARIA HEBRONENSIS, n. sp.

Plate 16, fig. 4

Test triangular, composed of numerous chambers, much compressed but rather broad especially near the lower angles; early chambers usually slightly coiled, succeeding chambers V-shaped with arms that become longer with each addition; walls of test smooth; sutures depressed; aperture terminal, round. Length, about 3 mm.

Locality, 6 miles north of Hebron.

NODOSARIA COMMUNIS (d'Orbigny)

Plate 16, fig. 5

Dentalina communis d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 254; Flint, Ann. Rep. U. S. Nat. Mus., 1897 (1899), p. 310, pl. 56, fig. 2.

Locality, 6 miles northwest of Irving.

ROBULUS CULTRATUS Montfort

Plate 16, figs., 6, 7

Robulus cultratus Montfort, Conch. Syst., vol. 1, 1808, p. 215, 54th genre.
Cristellaria cultrata Cushman, Bull. 71, pt. 3, U. S. Nat. Mus., 1913, p. 64, pl. 29, fig. 4.

Locality, 6 miles northwest of Irving.

GAUDRYINA FILIFORMIS Berthelin

Plate 16, fig. 8

Gaudryina filiformis Berthelin, Mem. Soc. Geol. France, ser. 3, vol. 1, 1880, p. 25, pl. 1, figs. 8 *a–d*.

Locality, 6 miles northwest of Irving.

GUEMBELINA GLOBULOSA (Ehrenberg)

Plate 16, fig. 10

Textularia globulosa Ehrenberg, Abhandl. K. Akad. Wiss. Berlin, 1838, p. 135, pl. 4, fig. B; Carsey, Univ. Tex. Bull. No. 2612, 1926. p. 25, pl. 5, figs. 2 *a*, *b*.

Locality, 6 miles northwest of Irving.

ANOMALINA EAGLEFORDENSIS, n. sp.

Plate 16, fig. 9 *a*, *b*

Test nearly symmetrical, much compressed laterally, composed of many chambers with about two and one-half convolutions visible; chambers somewhat flattened, forming umbilici slightly concave, eight or nine chambers in last-formed volutions; sutures depressed; periphery squarely angled; wall perforate; aperture at the middle of the base of the periphery of the chamber. Diameter, 0.7 mm.

This species is distinguished by the compressed shell with more or less square angles. It is very abundant in the Eagle Ford, especially in the upper beds.

Locality, 2 miles north of Hebron.

QUINQUELOCULINA STELLIGERA Schlumberger

Plate 16, figs. 11, 12

Quinqueloculina stelligera Schlumberger, Mem. Soc. Zool. France, vol. 6, 1893, p. 210, pl. 2, figs. 58 and 59, text fig. 17.

Locality, 6 miles northwest of Irving.

GLOBIGERINA CRETACEA d'Orbigny

Plate 16, figs. 14, 15

Globigerina cretacea d'Orbigny, Mem. Soc. Geol. France, ser. 1, vol. 4, p. 34, pl. 3, figs. 12–14.

Locality, 6 miles northwest of Irving.

GLOBOTRUNCANA ARCA (Cushman)

Plate 16, figs. 16, 17

Pulvinulina arca Cushman, Contrib. Cushman Lab. Foram Res., vol. 2, pt. 1, 1926, p. 23, pl. 3, figs. 1 *a–c*.

Globotruncana arca Cushman, *ibid.*, vol. 3, pt. 1, 1927, p. 91, pl. 19, fig. 11.

Globigerina rosetta Carsey, Univ. Tex. Bull. No. 2612, 1926, p. 44, pl. 5, figs. 3 *a–c*.

Locality, 2 miles north of Hebron.

BAIRDIA SUBDELTOIDEA (Münster)

Plate 16, fig. 18

Cythere subdeltoidea Münster, Neues Jahrbuch für Min., etc., 1830, p. 64; 1835, p. 446.

Cytherina subdeltoidea Roemer, *ibid.*, 1838, p. 517, pl. 6, fig. 16.

Locality, 6 miles northwest of Irving.

CYTHERELLA MUENSTERI (Roemer)

Plate 16, fig. 13

Cytherina muensteri Roemer, Neues Jahrbuch für Min. Geol., 1838, p. 516, pl. 6, fig. 13.

Cytherella muensteri Bosquet, Mem. Couron. Acad. Belg., vol. 24, 1852, p. 13, pl. 50, fig. 2.

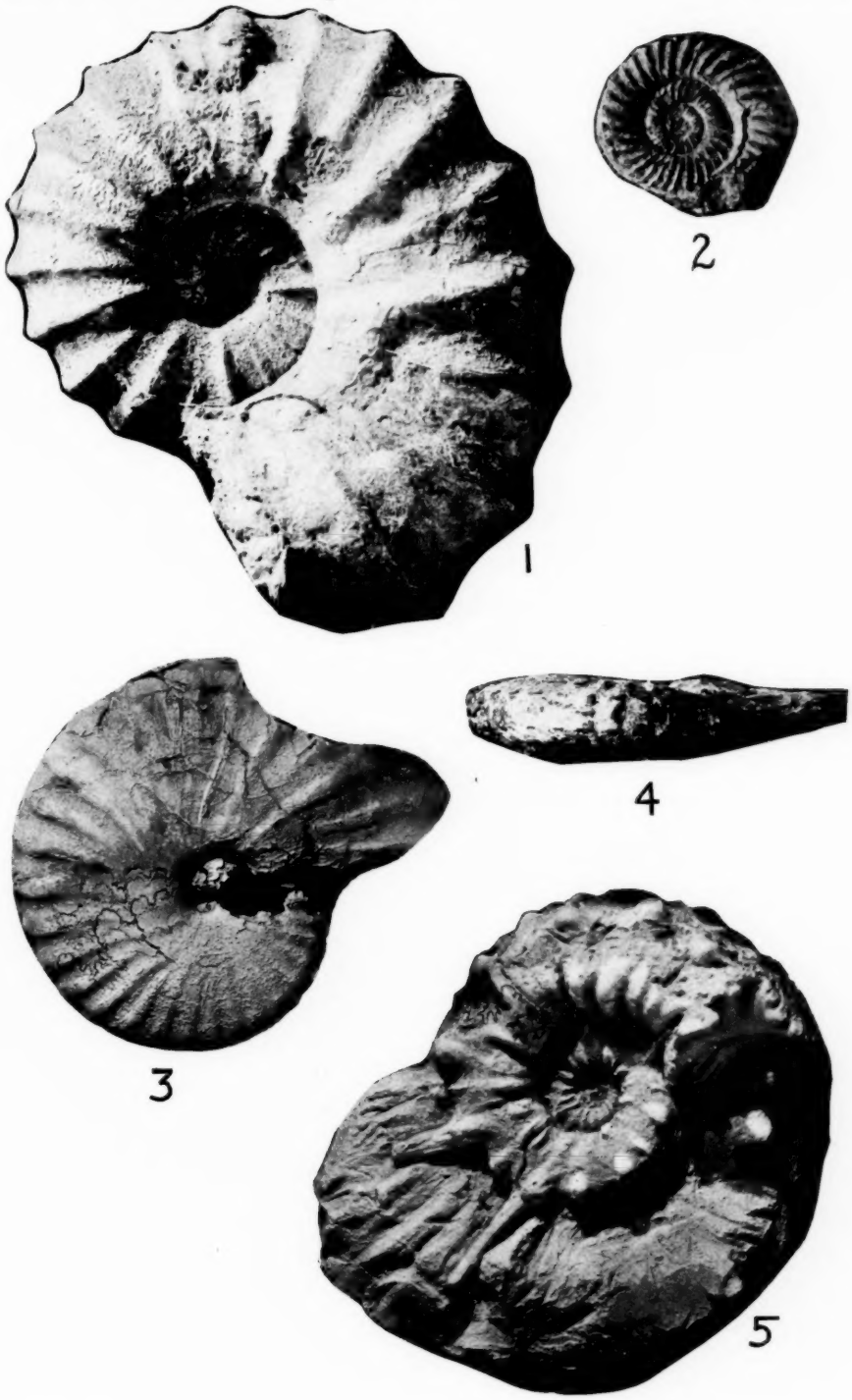
EXPLANATION OF PLATES

PLATE 13

FIG. 1.—*Acanthoceras* aff. *rotomagense* (de France), ×½.
2.—*Prionotropis* aff. *woolgari* (Mantell), ×2.
3.—*Metoicoceras irwini*, n. sp., ×½.
4.—Ventral view of same specimen, ×½.
5.—*Acanthoceras knabense* Stanton, ×1.

PLATE 14

FIG. 1.—*Hemitissotia* sp. A, ×1.
2.—*Gauthiericeras* aff. *bravaisi* (d'Orbigny), ×2.
3.—*Helicoceras pariense* White, ×1.
4.—*Metoicoceras gibbosum* Hyatt, ×1.

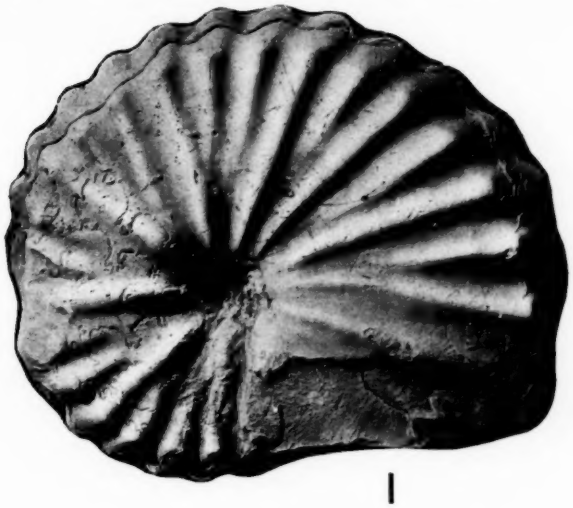

1
2
3
4
5

1

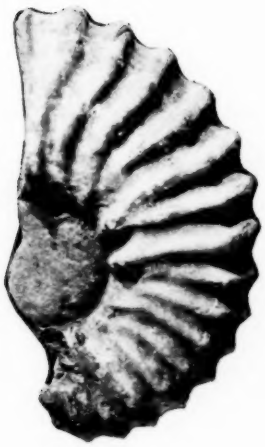
2

3

4

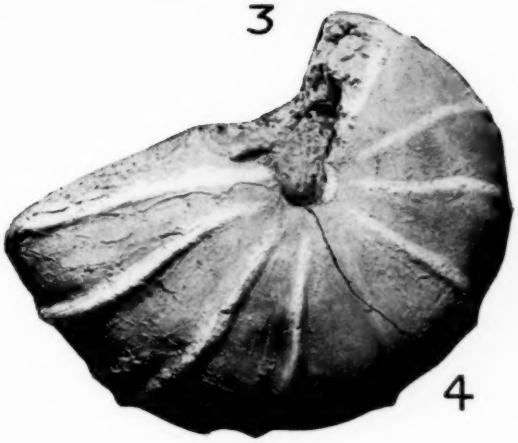


1



2

3



4

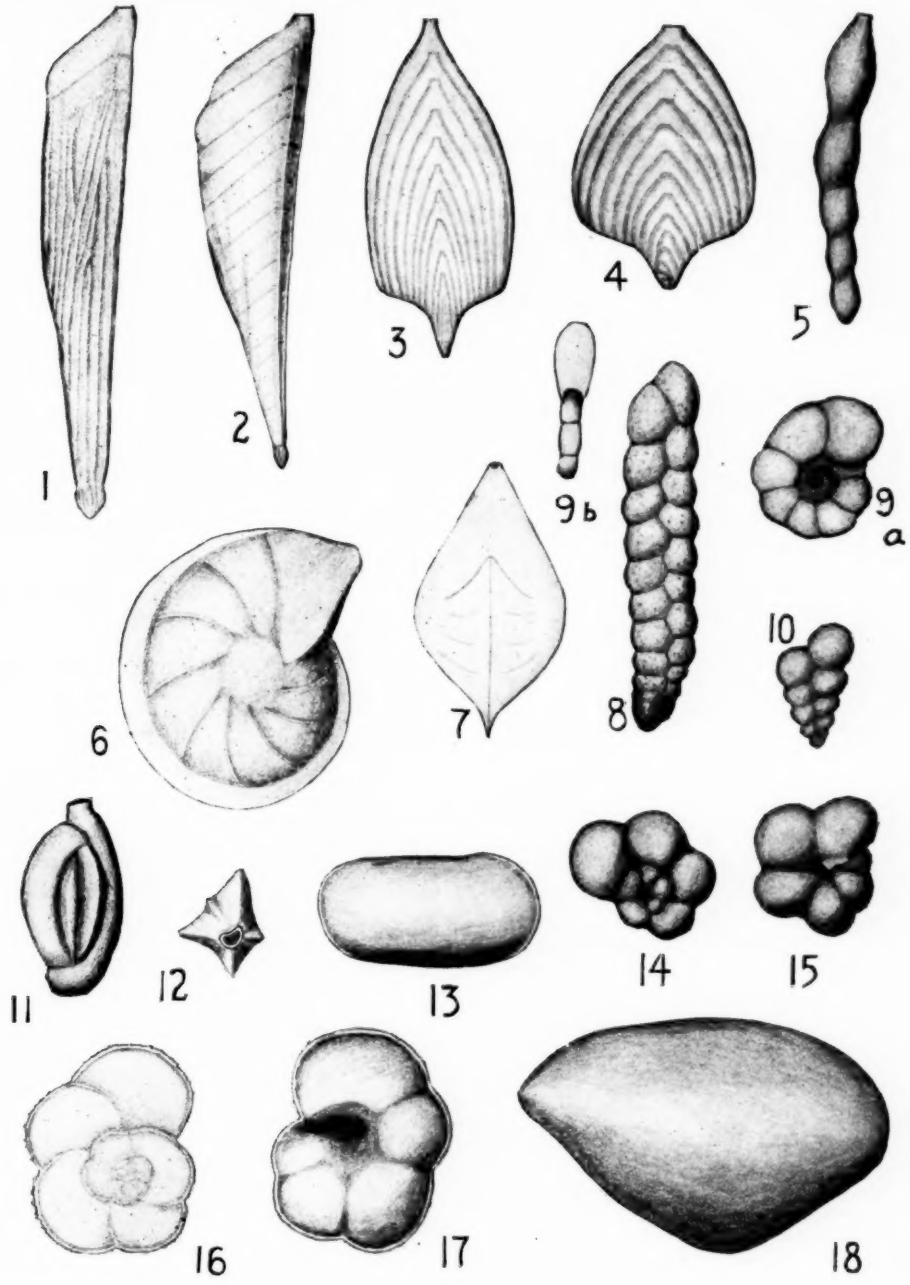

1
2
3
4
5
9b
9a
6
7
8
10
11
12
13
14
15
16
17
18

PLATE 15

FIG. 1.—*Metoicoceras whitei* Hyatt, ×1.
2.—*Acanthoceras* sp. A, ×1.
3.—*Metoicoceras swallovi* (Shumard), ×½.
4.—*Pachydiscus* sp. A, ×1.

PLATE 16

FIG. 1.—*Vaginulina simondsi* Carsey, ×25.
2.—*Vaginulina webbervillensis* Carsey, ×25.
3.—*Frondicularia alata* d'Orbigny, ×25.
4.—*Frondicularia hebronensis*, n. sp., ×25.
5.—*Nodosaria communis* d'Orbigny, ×50.
6.—*Robulus cultratus* Montfort, ×50.
7.—*Robulus cultratus* Montfort, section, ×50.
8.—*Gaudryina filiformis* Berthelin, ×50.
9.—*Anomalina eaglefordensis*, n. sp., ×50. *a*. ventral view; *b*. edge view.
10.—*Guembelina globulosa* (Ehrenberg), ×50.
11.—*Quinqueloculina stelligera* Schlumberger, ×50.
12.—*Quinqueloculina stelligera* Schlumberger, section, ×50.
13.—*Cytherella muensteri* (Roemer), ×50.
14.—*Globigerina cretacea* d'Orbigny, ×50.
15.—*Globigerina cretacea* d'Orbigny, ventral view of another specimen, ×50.
16.—*Globotruncana arca* (Cushman), ×50.
17.—*Globotruncana arca* (Cushman), ventral view, ×50.
18.—*Bairdia subdeltoidea* (Münster), ×50.